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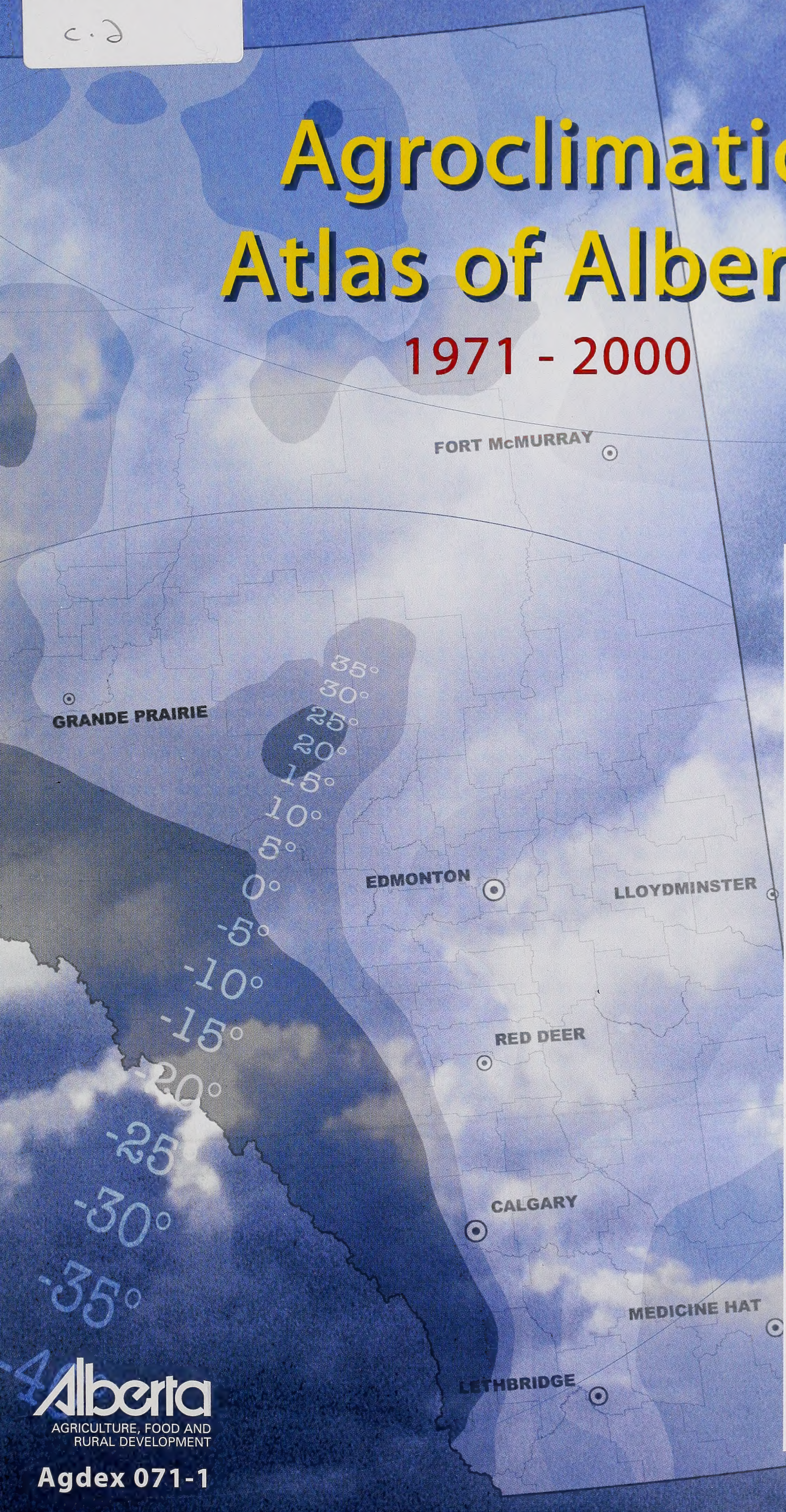
Agroclimatic Atlas of Alberta

1971 - 2000



Alberta
AGRICULTURE, FOOD AND
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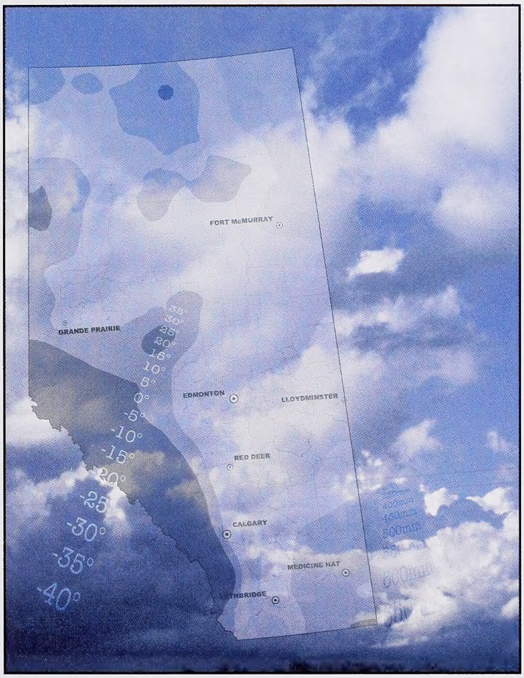

Shane Chetner, Editor-in-chief and the Agroclimatic Atlas Working Group

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AGROCLIMATIC ATLAS OF ALBERTA, 1971 – 2000

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INTRODUCTION

The purpose of this Agroclimatic Atlas is to present climatic information of importance to agriculture in Alberta and to make that information easily available to the agricultural community including agricultural producers, agribusiness and researchers.

Agriculture today is challenging agricultural producers charged with managing the risks associated with farming and ranching. Changes in technology, climate variability and new options for value-added crops mean producers require more detailed climate, soils and moisture information.

To address these needs, this new edition of the Atlas has been expanded with more agroclimatic maps, a chapter on soil moisture conditions in Alberta and a chapter on the soils and ecoregions of Alberta. These additions are intended to help make agricultural planning and decision making easier by providing this essential information in one location.

The previous edition, the 1951 to 1980 Agroclimatic Atlas of Alberta by Peter Dzikowski and Richard T. Heywood, was published in 1989 by Alberta Agriculture, Food and Rural Development. Since then, some important strides forward have been made in data quality control and analysis methods.

The maps in the 1951 to 1980 Agroclimatic Atlas were prepared by hand. The maps in this new edition have been created using various computerized mapping techniques that take into account some of the data limitations in terms of the number of stations, the station locations and the station records. For example, in the previous edition, data from some stations had to be adjusted to correct for local inconsistencies and for missing data where the station records were incomplete. The methods used in this new edition remove the need to adjust the data for such problems and allow the use of all available quality controlled daily climate data. (More information on the mapping methods is provided in *Interpolation of climate station data.*)

The Atlas describes the climate elements relevant to agriculture in Alberta and presents 29 maps of agroclimatic characteristics. The classes on each map are shown using different colours. In general red, orange and yellow colours represent warmer or drier conditions, while green, blue and purple colours represent wetter or colder conditions. The text provides examples to show how the climate information can be used for agricultural purposes. Figure 1 shows locations and physical features mentioned in the text, including cities, lakes, rivers, municipalities, agricultural areas, mountains and hills.

This 1971 to 2000 edition is also available on Alberta Agriculture, Food and Rural Development's website (www1.agric.gov.ab.ca). The website version includes maps for previous 30-year periods (1901 to 1930, 1911 to 1940 and so on to 1961 to 1990) and will be updated with additional maps as they become available.

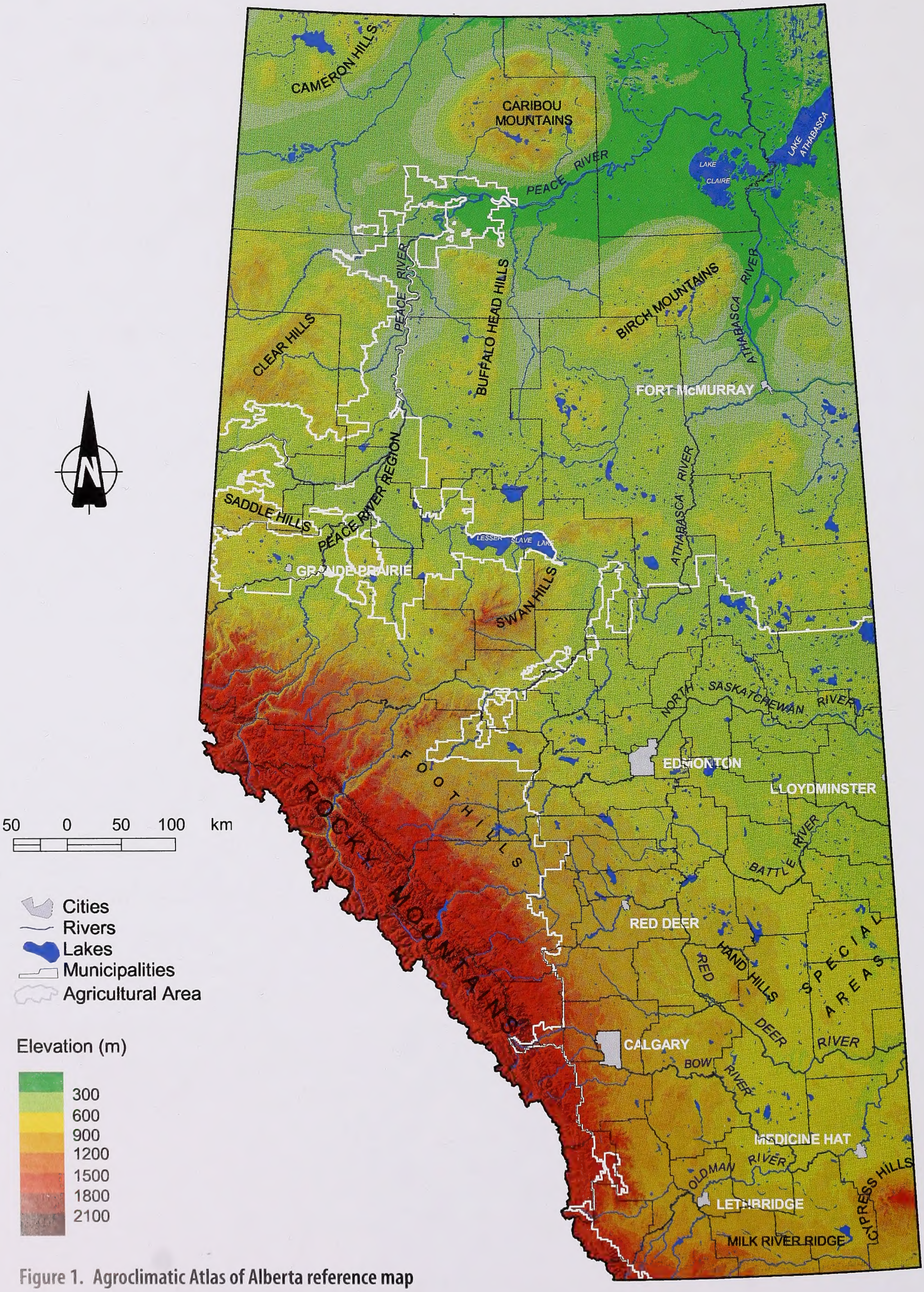


Figure 1. Agroclimatic Atlas of Alberta reference map

CLIMATE BASICS

Climate and weather are key factors in agricultural production. For example, they influence what crops can be grown in a region, the yearly variation in crop and pasture yields, and the amount of water available for livestock.

There is a difference between weather and climate. ***Weather*** is what is happening in the atmosphere now and over a short period of time. It is described as wet or dry, hot or cold, cloudy or clear, and windy, stormy or calm. ***Climate*** is the long-term average weather conditions describing what generally happens. In other words, climate is what you expect, and weather is what you get.

Four factors determine climate for a given location:

- position on the globe
- ratio of water to land
- wind systems
- topography

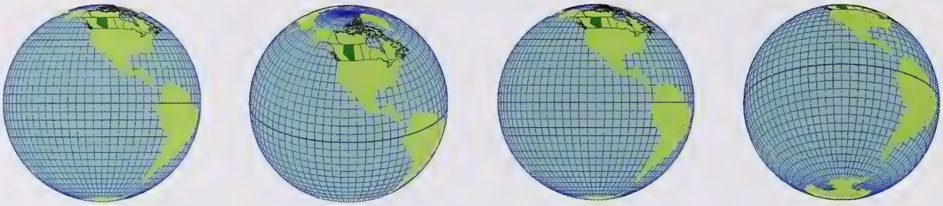
How far north or south you are from the equator has the biggest effect on climate. Both the intensity of the sun's radiation and wind circulation patterns change with latitude.

The sun's rays are responsible for heating the earth's surface. Energy from the sun travels about 150 million kilometres (km) through space to our planet. About half of the energy passes through the earth's atmosphere and reaches the earth's surface. The other half is reflected back into space by clouds, scattered by dust particles and water vapour, and absorbed by the gases in the atmosphere and re-radiated.

The amount of solar radiation received at the surface varies with two factors that depend on latitude (Figure 2).

The first factor is the angle of the sun's rays. When the sun appears to be directly overhead (as it is at noon at the equator during the spring and fall equinoxes), the sun's rays are at their most intense. Towards the poles, the sun is lower in the sky, so its rays are more slanted and the same amount of radiation has to pass through more atmosphere and is spread over a wider area on the earth's surface. So the sun's radiation is most intense at the equator and least at the poles.

The second factor is the hours of daylight. At the equator, the seasonal difference in the hours of daylight is small. As you move toward the poles, the hours of daylight become longer in summer and shorter in winter.



Spring Equinox **Summer Solstice** **Fall Equinox** **Winter Solstice**

The side of the earth facing the sun, at noon on the days of seasonal extreme. The differences in the length of daylight and the amount of solar radiation Alberta receives on these days, are directly related to the differences in the apparent size of Alberta (from the perspective of the sun) on these days.

			Daylight Length			
	Latitude	Longitude	March 21	June 21	September 21	December 21
Lethbridge	49° 38′	112° 48′	12 h 13 min	16 h 19 min	12 h 16 min	8 h 12 min
Red Deer	52° 11′	113° 54′	12 h 14 min	16 h 46 min	12 h 17 min	7 h 38 min
Grande Prairie	55° 11′	118° 53′	12 h 15 min	17 h 25 min	12 h 19 min	7 h 8 min
Fort McMurray	56° 39′	111° 13′	12 h 16 min	17 h 48 min	12 h 19 min	6 h 48 min

Figure 2. Effect of latitude on seasonal solar radiation and day length

As a result of these two factors, the polar regions of the earth receive less energy from the sun than does the equatorial region. Canada's position in the northern portion of the earth's northern hemisphere means that it receives less radiation compared to countries nearer the equator. The northward decrease in solar radiation is noticeable in Alberta (Figure 2 and Map 25). Cropping is successful in the northern agricultural area of Alberta because the longer summer day length helps compensate for the less intense solar radiation.

Warmed by the sun's radiation, the earth's surface gives off heat. The air above the earth is warmed by this heat, rather than being directly heated by the sun's rays. The amount of heat given off by the earth depends in part on whether the surface is made of water or land. Water bodies warm up and cool down relatively slowly, and maintain moderate temperatures. Land surfaces warm up and cool down more quickly, and reach more extreme temperatures. Large areas of land and water have a strong influence on the temperature and humidity of the air masses above them.

When solar radiation heats up water bodies, some of the water evaporates. The heat stored in the water vapour is released when the vapour condenses to form water droplets. This released energy drives storm systems like thunderstorms, hurricanes and tornadoes. Water vapour is an important vehicle for the transport of stored energy (called ***latent heat***) and helps regulate the earth's temperature.

Air masses are huge bodies of air, usually several hundreds of kilometres across. Temperature and humidity change gradually within an air mass. The moisture content of an air mass is determined by whether it was formed over an ocean or a continent, while its temperature is primarily influenced by latitude. The movement and interaction of air masses create weather.

The general wind circulation in the atmosphere is driven by the exchange of heat between the cold polar regions and the hot equatorial region. This heat exchange prevents the equatorial region from becoming progressively hotter and the polar regions from becoming progressively colder. As the tropical and polar air masses try to move north and south, the rotation of the earth deflects their movement. In Canada, this deflection results in a wide belt, covering the latitude of the Canadian Prairies, known as the zone of the ***westerlies***, so-called because that is the direction from which the wind most commonly blows.

The interaction of the westerly winds with land and water affects climate patterns in Canada. For example, the westerlies blow sea air onshore – mild air in winter and cool air in summer – to give coastal British Columbia its moderate climate. In the Maritimes, the prevailing westerlies blow offshore, giving the east coast a climate more similar to that of Ontario and Quebec. Westerly winds can vary greatly in duration and intensity.

Oceans act as huge storage areas for heat. They absorb heat in spring and summer, and release heat in fall and winter. The oceans also transfer heat and cold around the world in great ocean currents. For instance, the Japanese Current brings warm water to British Columbia's coast, while the Labrador Current on Canada's east coast moves cold Arctic water southward. These ocean currents give adjacent land areas higher or lower temperatures than they would otherwise have and help account for the differences in climate between coastal British Columbia and Newfoundland.

Topography, the physical features of the landscape, is another major factor affecting climate. In western Canada, the Rocky Mountains force air masses from the west to rise and drop their moisture as precipitation, creating wet conditions on the west side of the mountains and drier conditions on the east side. Mountain ranges can also deflect the motion of air masses so that they move parallel to the mountains. Changes in elevation on a smaller scale affect regional or local climates. For example, valleys have very different climates from those of the surrounding level areas.

WEATHER IN ALBERTA

Weather in Alberta is produced by the interaction of air masses with different temperature and moisture characteristics. The properties of these air masses vary with the season, with whether the air mass was formed over land or sea, and with the latitude of the air mass's area of formation.

In the winter, Alberta's weather is dominated by the maritime polar and the continental polar air masses. The maritime polar air mass from the north Pacific is moist, providing moisture for snow in the mountains and to a lesser extent over the prairies. The continental polar mass, formed over Canada's interior, is dry and cold. Occasionally the continental arctic air mass advances into Alberta from the far north, creating intense cold weather.

In the summer, Alberta's weather continues to be dominated by the maritime and continental polar air masses, but maritime tropical air masses from the Gulf of Mexico and from the Pacific sometimes enter Alberta, often bringing significant moisture.

Air masses and their cold and warm fronts account for the daily precipitation and temperature conditions under which agricultural managers operate.

Frontal precipitation

The boundary between air masses with different properties is called a front. A cold front occurs when cold air advances towards warm air. It pushes under the warm air, causing it to rise, cool and create precipitation. A warm front occurs when warm air overrides cold air, which can also result in precipitation.

In general, warm fronts generate more precipitation over a larger region than do cold fronts. The passage of a cold front is more likely to produce severe weather events, including heavy rain, hail and tornadoes, than the passage of a warm front.

The greatest precipitation amounts occur in Alberta when moist air finds its way into the province from either the Gulf of Mexico or the Pacific Ocean off California. This usually happens when a large low pressure system moves toward Alberta from the south.

Storm systems are always low pressure systems. Low pressure systems have central barometric pressures lower than their surroundings. High pressure systems have central barometric pressures higher than their surroundings. The circulation or motion around a low pressure system is counterclockwise in the northern hemisphere, clockwise in the southern hemisphere and undefined at the equator. The circulation around a high pressure system is the opposite of that around a low pressure system.

Convective precipitation

Convective precipitation occurs when the air near the ground is heated by the earth's warm surface. This warm air rises, cools and creates precipitation. The moisture sources for convective storms are the moisture contained in the air mass and the moisture evaporated from the earth's surface and transpired by vegetation.

Convective storms or showers account for about 40 per cent of summer rainfall. The amount of rain produced by any shower can vary greatly. Sometimes the rain evaporates before it reaches the ground; at other times, rainfall amounts are substantial, as in the case of thunderstorms. The rainfall amount and intensity can vary greatly over short distances. Heavy showers can produce significant runoff, which can result in serious ***water erosion*** (the removal of soil particles by water).

Topographic precipitation

Topography can play a role in creating precipitation. Air is lifted when it passes over rising ground. As the air rises, it cools and if it rises sufficiently and contains enough water, precipitation will occur. Topographic effects can increase the amount of precipitation received from frontal or convective storms. For example, the Milk River Ridge, Hand Hills and Clear Hills have higher precipitation than surrounding areas (see Figure 1).

In southern Alberta, moist air masses from the Gulf of Mexico push up against the foothills of the Rocky Mountains. The rising land adds topographic effects to the frontal rainfall, leading to major widespread rain in the foothills and western prairies. The moist, southeasterly winds and increasing elevation can also create ground fogs several thousand metres deep in southwestern Alberta. This form of weather is so common at Lethbridge that the instrument landing system at the Lethbridge Airport is designed primarily to deal with it.

Chinook winds

Chinooks are warm, dry winds that descend on the eastern side of the Rocky Mountains, primarily in Alberta and Montana. The term "chinook" is derived from the name of a First Nations tribe living along the Columbia River (from the Salishan word "Tsinuk"). The term was originally used to refer to a wind that blew from the direction of the tribe's encampment.

Chinook winds often have a distinctive arch cloud with a sharp western edge that runs parallel to the Rocky Mountains. A chinook arch can stretch for a few hundred kilometres. The shape of the arch is due to both the cloud height and the large cross-wind extent along the horizon.

The process for creating a chinook begins as warm, moist air from the Pacific Ocean moves over the three mountain ranges in British Columbia. As the air climbs up the western side of each mountain range, it cools. Warm, moist air cools at a rate of 0.5 to 0.8°C for every 100-metre (m) rise in elevation, depending on the amount of moisture available. The cool, moist air forms clouds and fog, and some of the moisture in the air falls as rain or snow. As the air descends on the leeward side of the mountain range, the air heats up. Dry air heats up faster than wet air, warming at the rate of about 1°C for each drop of 100 m.

Each time the air rises over another mountain range, it loses more moisture, and each time the air descends, it becomes warmer. The process of wet air cooling and dry air warming over the mountains is called the ***orographic effect***. By the time the air descends on the eastern side of the Rocky Mountains, it is much warmer and drier.

The conditions required for a chinook to occur include a high pressure weather system in western British Columbia and a low pressure weather system in the lee of the Rocky Mountains. The strength of the chinook depends on the moisture content of the air that flows between the high and low pressure systems, the pressure differences between the two systems and the topography of the affected area.

The atmospheric processes that produce a chinook occur year-round, but the effects are most pronounced during the winter when temperature increases of 25°C or more within a few hours are possible. The chinook effect is most significant in southwestern Alberta, where these winds frequently remove the snow cover. Farther from the mountains, the effect is usually less dramatic as the air temperature near the ground may rise by only a few degrees.

Figure 3 shows the chinook zone of Alberta based on a definition developed by Longley (1972). He defined the chinook zone as the area with 20 or more days of maximum temperatures greater than of 5°C during December, January and February.

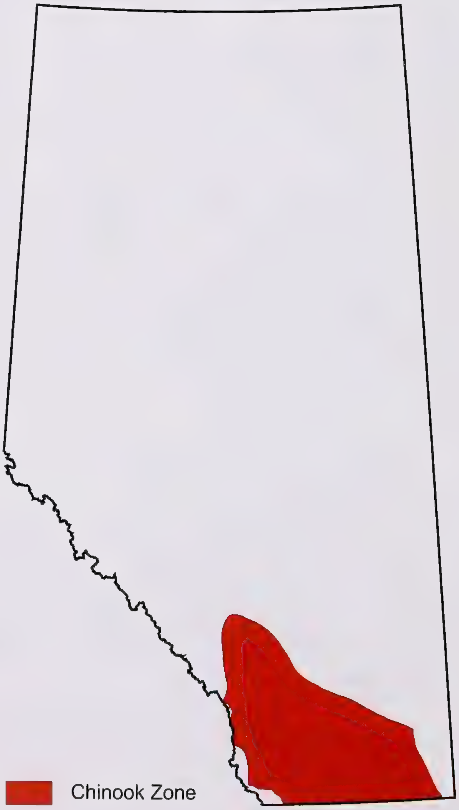


Figure 3. Chinook zone of Alberta

The strong, gusty chinook wind can be unpleasant and can result in physiological as well as psychological reactions in humans such as headaches and increased irritability. Chinooks can have positive or negative effects for agriculture. For example, the high evaporation can increase plant water stress in areas already suffering from low precipitation, while the reduced snow cover can lengthen the grazing season and decrease the amount of stored feed required.

Severe weather

Severe weather is any destructive storm, but the term is usually used for intense local storms. Examples include hail storms, heavy rains, gusty winds, high winds and tornadoes. In general, severe weather events have a significant effect, but the effect is concentrated in a small area.

Severe weather events occur in Alberta and can cause significant problems for agriculture. In the case of heavy rain, the risks to agriculture may occur at some distance from the storm itself because heavy rains in high areas can produce downstream flooding. Efforts are currently underway to improve prediction and provide advance warning of severe weather, so people can take measures to prevent loss of life and property. Insurance (general and crop) provides a way to reduce the economic impact from these kinds of losses.

Extreme weather

Extreme weather is weather that occurs outside the normal range of weather intensity for a location. It is infrequent or rare and can produce a damaging effect, although not all extreme weather events end in disasters. An extreme weather event becomes a disaster when the resulting damage is beyond the capacity of a community or system, such as an agricultural production system, to cope.

Extreme weather can create significant problems for agriculture. Examples of extreme weather include heat waves, cold spells, dust storms, prolonged dry periods, prolonged wet periods and summer snowstorms.

Some extreme events occur because of a combination of factors. For instance, the merging of two weather systems, the occurrence of a severe weather event combined with another factor, or consecutive years of very low precipitation can lead to an intense impact.

While drought is a natural and repeating occurrence on the prairies, when serious droughts occur in consecutive years, they are considered climate extremes. The 2001 drought, for example, was a disaster for Alberta producers, costing the province's economy billions of dollars. In 2002, the impact of the drought intensified as a result of the record low precipitation levels in the central and Peace regions of Alberta. The multi-year droughts combined with a record number of days above 30°C and an outbreak of grasshoppers made 2002 even worse for agriculture in many parts of Alberta.

Protection against extreme events can be planned in some cases but not in others. With stock watering supplies, it is possible to estimate requirements and construct adequate water storage to reduce the risk of shortage, but at a cost. In dryland farming, reduced and zero tillage systems are used to conserve soil moisture in the event of inadequate rainfall; however, even under these tillage systems, crops will be affected by prolonged drought. Insurance plans, such as crop or forage insurance, are an important way to reduce the financial risks and consequences of extreme weather.

Weather lore

Weather lore is based on both fact and fiction. It is often passed on from generation to generation even if circumstances have changed. The lore is often contained in a catchy rhyme such as:

"An evening grey and morning red will send a shepherd wet to bed."

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This statement tested for London, England, proved right 70 per cent of the time. This piece of lore has a sound scientific basis. Weather systems approach from the west and are often preceded first by high thin cloud, then increasingly thick clouds at lower altitudes. This accounts for the grey at sunset. In the morning, the long path the sunlight takes through the atmosphere, indicating no clouds to the east, causes the red at sunrise. The normal dusty atmosphere allows the sun's red rays to pass through to a greater extent than the blue rays, making the sky appear red.

Generally weather and climate lore must be applied in the environment for which it was developed. For example, in southwestern Alberta, the presence of a chinook arch usually results in warm and windy conditions. A similar looking cloud seen elsewhere will not foretell this event.

Some weather lore is linked with recurring events that have general applications. Over 2000 years ago, the Greeks recognized that sun haloes (sun dogs) foretold rain. Modern day studies confirm that this is generally a valid prediction. Sun dogs are produced by small ice crystals in the atmosphere. These crystals increase as an air mass becomes wetter. When sunlight strikes the ice crystals, the crystals break up the light into its component colours in the way that a prism does.

Roger Bryan

Some lore is based on plant and animal activities, such as Groundhog Day. Although such lore has been severely criticized in the past, these sayings have recently gained some credibility because many creatures are much more sensitive to slight changes in temperature, pressure and humidity than humans are, and their reactions can provide some indications of a change in weather.

Some reservations should be kept in mind when applying lore. Lore is usually based on what is best remembered rather than what normally happens; violent or rare events often stick in the observer's mind more than routine events. Also weather lore is often based on regional conditions. These conditions may not apply to individual locations, especially with respect to weather elements like frost that are strongly affected by the local characteristics.

Linked with lore, there are recurring events such as "Indian Summer," "in like a lion, out like a lamb" (the March forecast), "Groundhog Day," and the "Bonspiel Thaw." These do not always happen but occur with sufficient frequency to be accepted as more than the result of chance.

CLIMATE OF ALBERTA

Alberta has a continental climate with warm summers and cold winters. The agricultural area of the province (shown on Figure 1) has a semiarid climate because the annual precipitation is less than the water evaporated by the wind and heat, and transpired by plants.

The distribution of temperature and precipitation in Alberta results mainly from the shifting boundary between air masses. The most common air masses are the maritime polar, continental polar, maritime tropical, and continental arctic. Usually only two of these air masses will be found over the province at a given time. As the fronts between the air masses shift north and south across Alberta, temperature can change rapidly. The boundary between the two air masses will often be in the extreme north of the province in the summer and across the central part of the province in the winter.

Temperatures are generally higher in southern than northern Alberta because the south receives more solar radiation (Figure 2 and Map 25). In July, the average daily temperature ranges from warmer than 18°C in the south to cooler than 13°C in the Rocky Mountains and the north (Map 5). In January, the average daily temperature ranges from cooler than -24°C in the far north to warmer than -10°C in the south and the mountains (Map 4). The warming effect of the chinook winds near the mountains produces a west to east trend in winter temperatures. The range of average temperatures across the province in winter is greater than in summer because of the reduced heating from the sun at northern latitudes.

Arctic air masses in the winter produce extreme minimum temperatures varying from cooler than -54°C in northern Alberta to warmer than -46°C in southern Alberta (Map 6). In the summer, continental air masses produce maximum temperatures from 32°C in the mountains to warmer than 40°C in southern Alberta (Map 7). These air masses can move quickly in the spring and fall resulting in rapid seasonal changes.

Precipitation is generally highest along the mountains and into west central Alberta due to the combined effects of frontal and topographic precipitation (Map 1). Precipitation from May 1 to August 31 varies from slightly below 200 millimetres (mm) in the driest prairie areas to more than 325 mm in the mountains (Map 2). From September 1 to April 30, precipitation ranges from less than 150 mm in the driest prairie region to more than 275 mm in the mountains (Map 3).

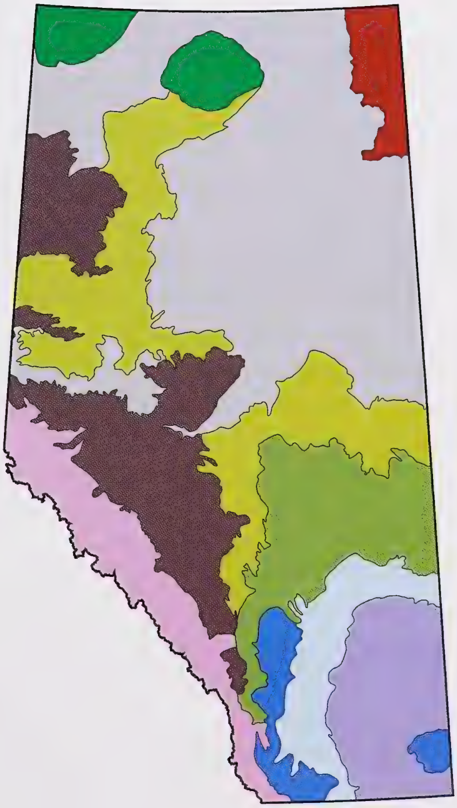
Alberta is a sunny province. Annual bright sunshine totals range between 1900 and 2500 hours per year. Northern Alberta receives about 18 hours of daylight in the summer. The long summer days make summer the sunniest season of the year in Alberta.

Climate regions

In general, climate regions can be represented by ecoregions (Figure 4). An ***ecoregion*** is an area of similar climate, physiography, vegetation, soil, water, fauna and land use characteristics. Climate strongly influences many of the other characteristics in an ecoregion, such as soils, vegetation, water, fauna and land use.

In the agricultural area of Alberta, the Mixed Grasslands in southeastern Alberta have the lowest precipitation and hottest summers. Moving west and north through the Moist Mixed Grasslands, Aspen Parkland, Boreal Transition and Western Alberta Uplands, the climate becomes moister and cooler. The Peace River Region (see Figure 1) is an exception, with relatively warm summer temperatures and low precipitation for its latitude. The long summer day length in the Peace River Region improves the agricultural potential of this area.

For more information on Alberta's ecoregions, see *Soils and ecoregions in Alberta.*



Ecoregions

🟩 Aspen Parkland
🟥 Athabasca Plain, Tazin Lake Upland
🟦 Fescue Grasslands, Cypress Hills
⬜ Mixed Boreal Uplands, Slave River Lowland, Wabasca Lowland
🟪 Mixed Grassland
⬜ Moist Mixed Grassland
🟩 Northern Alberta Uplands
🟨 Peace Lowland, Boreal Transition
🟪 Subalpine, Alpine
🟫 Western Alberta Uplands, Clear Hills Upland

Figure 4. Ecoregions of Alberta

Farm climate

The climate on any farm or any field may differ from that of the area around it. Factors such as local variations in elevation and farm management practices influence farm climate.

The local topography has a marked effect on the incidence of frost. After sunset, the ground cools rapidly. The layer of air immediately above the ground cools, becomes heavier and tends to drain down the land slope and to collect in depressions and hollows. In these frost pockets, this cold air drainage results in much earlier frosts in the fall and later frosts in the spring than found in surrounding areas. Hillsides on average have longer frost-free periods than lower areas and valleys. Conditions for cold air drainage exist when there is no general air movement. Even a light wind will mix the thin, cold surface layer of air with the relatively warm air above it. Moderate winds will quickly equalize the temperatures.

South- and west-facing slopes receive more direct radiation from the sun and tend to be warmer and drier than east- and north-facing slopes. These effects can be either positive or negative depending on crop type and precipitation.

Farm management may affect temperature and moisture conditions. For example, maintaining a crop residue cover to catch snow can increase soil moisture but may also slightly reduce surface soil temperature in the spring. The residue cover intercepts some heat, and wet soil warms up more slowly than dry soil. However, the added moisture for crop growth and the protection from ***soil erosion*** (removal of soil particles by wind or water) provided by the residue cover more than compensate for the slight decrease in spring soil temperatures. Soil erosion results in lower soil productivity and can also harm water quality and air quality.

Microclimate

Microclimate is the climate of any small area. Microclimates can exhibit conditions that are distinct from the surrounding area. The characteristics of the soil surface, such as whether it is bare or covered with plants, have a great influence on the microclimate. A sheltered area has a different microclimate than an open field. Generally, warmer daytime temperatures are found in river valleys. Two examples are along the Peace River at Dunvegan and at the town of Peace River where vegetables thrive. Cooler temperatures are found at higher elevations, such as the tops of the Cypress and Hand Hills (see Figure 1).

Data collection

Weather and climate stations

The maps in this Atlas are based on climate data from over 1200 stations in Alberta and from about 1400 stations bordering Alberta in British Columbia, Saskatchewan, Yukon, Northwest Territories, Nunavut and the United States.

Two types of stations record climate data. ***Synoptic weather stations*** typically report near real-time (hourly, 6-hourly, daily) automated weather information using a communication system (satellite or modem). They collect detailed data on air temperature, precipitation amount and intensity, wind speed and direction, humidity and dew point temperature. The information from these stations is used in preparing weather forecasts and in calculating climatic information.

Climate stations typically report less frequently (daily, twice-daily, weekly, monthly) and may be automated or manually operated by volunteers. These stations collect daily temperature and precipitation information, and some used to collect precipitation only.

Figure 5 shows the locations of stations operating during the period from 1971 to 2000. The number of stations in operation changes over time. In 2002, there were about 300 synoptic weather stations and 325 climate stations operating in Alberta. These stations are part of various provincial, federal and independent networks, described below. Each of these networks collects data for specific purposes, depending on the collecting agency's information needs. Not all of the networks described below provided data used in this Atlas.

Environment Canada receives the majority of the data from the federal and provincial networks, performs quality control on the data, and stores the data in the National Climate Archives in Montreal. Data from the United States stations are provided by the U.S. National Climate Data Center.

Alberta Government networks

Alberta Agriculture, Food and Rural Development operates two weather station networks: DroughtNet AGDM and Irrigation Network.

Alberta Environment operates stations located mostly in the mountains and foothills. These stations monitor conditions for use in flood river forecasting. Many of the stations are located on rivers, lakes, ridges, headwaters, coulees and creeks. Alberta Environment also has an air quality monitoring network.

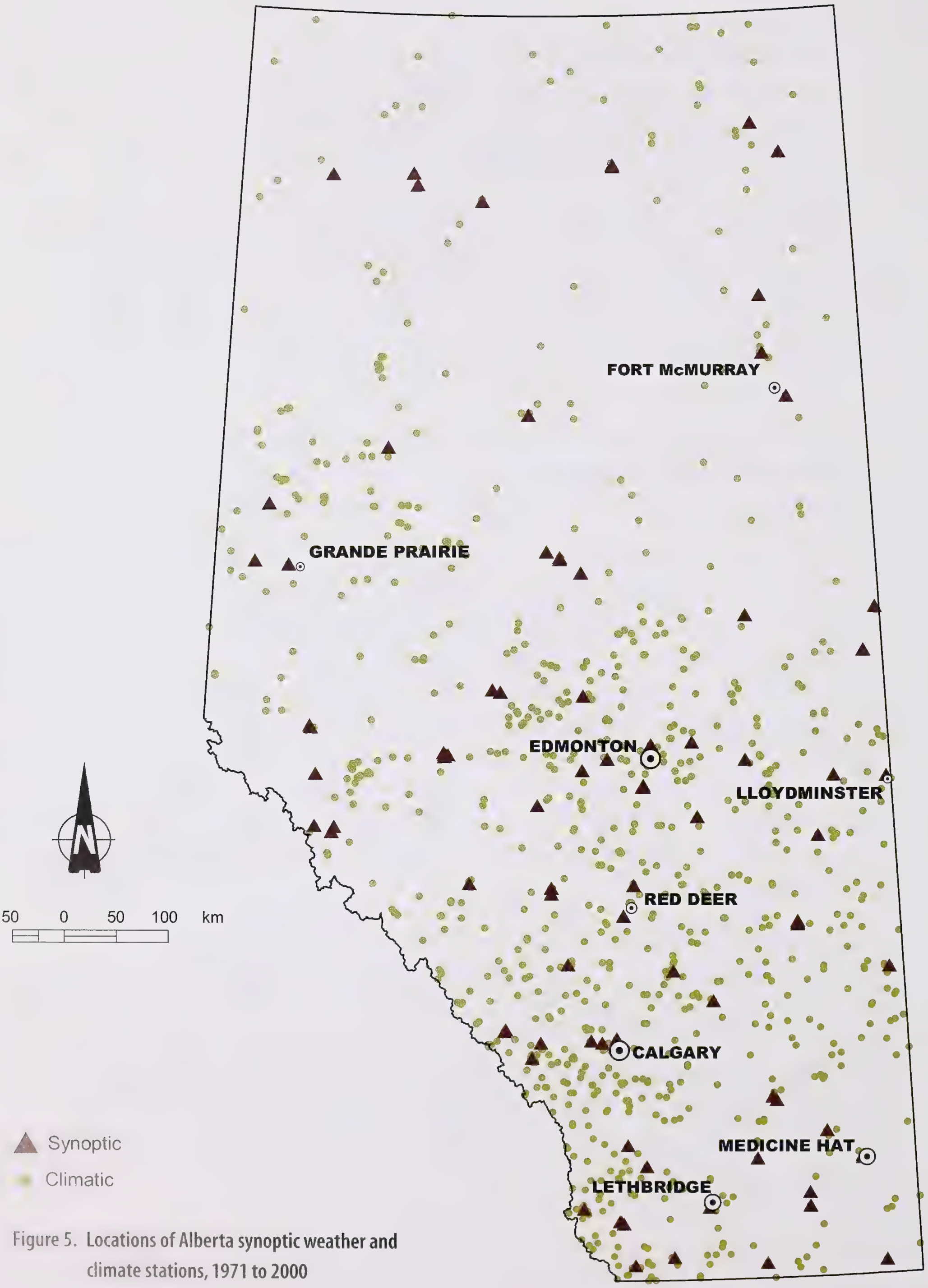


Figure 5. Locations of Alberta synoptic weather and climate stations, 1971 to 2000

Alberta Sustainable Resource Development operates synoptic stations and climate stations mostly in Alberta's forested regions. These stations monitor weather conditions related to forest fire prevention and control.

Alberta Transportation operates a few weather stations in Edmonton and Calgary for monitoring road safety.

Federal Government networks in Alberta

Environment Canada operates several networks in Alberta including:

- the reference climate station network, which collects climate data for climate change, global warming, etc.
- the upper air network, which collects data for weather forecasting and air quality.
- the surface weather network, which collects data for public weather forecasting and warnings.
- the temperature and precipitation network, which collects climate data for historical, social and economic reasons including data for special interest groups such as agricultural hail and crop insurance programs. A volunteer network reports temperature and precipitation data either daily or twice daily. Most stations send in their forms once each month, but an increasing number of stations are reporting daily via the Internet or an automated 1-800 phone system.

Transport Canada has privatized the air navigation system as a not-for-profit company known as NavCan. NavCan operates weather stations at many of the airports in Alberta.

Agriculture and Agri-Food Canada operates several automated weather stations at agricultural research stations in Alberta.

Other networks in Alberta

A few weather networks operate independently in Alberta for research or monitoring purposes.

Station names

Some stations have acronyms after the station name. The most common acronyms are:

- RS – ranger station
- LO – lookout tower
- AFS – Alberta Forestry Service (the former name of what is now part of Alberta Sustainable Resource Development)
- A – airport

- CDA – Canada Department of Agriculture (the former name of Agriculture and Agri-Food Canada)
- AGDM – Agricultural Drought Monitoring station

Instrumentation

Thermometers to measure maximum and minimum air temperature and sensors to determine relative humidity and dew point temperature are placed 1.2 m above the ground in a shelter called a Stevenson screen. The shelter has horizontal, overlapping slats that protect the thermometers from direct sunlight and precipitation, while allowing air to circulate around them.

Rainfall is measured by catching it in a calibrated rain gauge. At most climate stations, a volunteer observer measures rainfall intensity using a standard Canadian rain gauge called a Type B rain gauge. The gauge sits about 40 centimetres (cm) above the ground and has a circular opening 11.3 cm in diameter. The rain is funneled into a clear plastic cylinder, which measures the contents to the nearest 0.2 mm.

The majority of climate station observers measure the depth of new snow using a ruler. They estimate the amount of moisture in the snow by assuming a snow density of 100 kilograms per cubic metre. Snow depth is read to the nearest 0.2 cm, with less than 0.1 cm is recorded as a trace. The Canadian Nipher Shielded Snow Gauge System is the standard instrument for measuring fresh snowfall water equivalent. It is used at a limited number of stations.

The synoptic weather stations collect wind speed and direction at a height of 10 m above the ground. These stations also measure atmospheric pressure, visibility, cloud cover and type, hours of bright sunshine, solar radiation and, in a few cases, snow depth and evaporation.

Standards

All data used in preparing the maps and tables in this Atlas meet the standards of the World Meteorological Organization (WMO). The WMO publishes the Guide to Meteorological Instruments and Methods of Observations (Reference #6008-2). That guide describes the basic standards of instrument and observing practices required by current international meteorology. It also provides the basis for the preparation of detailed instrument manuals by individual meteorological services for use by their observers. People setting up a weather station should try to follow the WMO standards.

Mapping climate data

Each synoptic weather station or climate station provides data for the location of that station, a single point on the surface of the earth. Using such point information to prepare maps of an area requires ***interpolation***, the calculation of the likely values between the points where measurements are taken.

All available quality-controlled data were used in the interpolation procedures for this Atlas. The available data are limited in time and space. A weather or climate station may open, close or move to another location over time. Historically, relatively few synoptic stations operated in the agricultural areas of Alberta during the 1901 to 2000 period. Most synoptic stations were located in the mountain and forested areas and at airports. In addition, many stations represent the local area, not the larger agricultural region.

Climate elements such as temperature and precipitation were calculated for each township of Alberta using an interpolation process. (The Alberta Township Survey System is a grid network with each township being 6 miles by 6 miles in size.) The township climate data were smoothed using computer graphics software. As a result of interpolation and smoothing processes, small differences are introduced when comparing the actual station data and the maps.

The Rocky Mountain area appears white on all the maps. This is because the extreme differences in topography and the limited data available for this area make the interpolation procedure unreliable.

For more details about the interpolation methods used to create the agroclimatic maps in this Atlas, see *Interpolation of climate station data.*

Climate normals and extremes

A long period of weather observations is necessary to understand the climate. Like weather, climate also changes but very gradually. A 30-year period is used in this Atlas to describe the present climate because it is long enough to filter out short-term fluctuations, but is not overridden by any long-term trend in the climate.

Climate normals are the average values for climate characteristics such as temperature, precipitation, wind and humidity. In this Atlas, the climate normals are based on the data for the latest 30-year period, which is 1971 to 2000. The 30-year period is updated only every 10 years because of the massive amount of work involved, and the fact that the average values would not change in a year.

Average values allow quick and easy comparison of the climate of different areas, but they do not describe the inherent variability of climate at any given location. Year-to-year variations result in values that are usually above or below the average. Variability is an expected feature of our climate, which must be remembered when looking at the average values presented in this Atlas.

Climate information is used as a long-term planning tool, for example, in selecting a location for a farm or planning a cropping program. The average is sometimes not adequate for planning because extreme events can disrupt long-term plans. Therefore, this Atlas provides some maps about extremes.

Caution must be used when dealing with data on extreme values because the period of record is very important. The shorter the period of record the less reliable the extreme. If you want to know how much snow was dropped by the worst storm in 100 years, you can not expect a station with only 20 years of records to provide it. The shorter the period of record, the more likely it is that a unique extreme event has been missed.

Maps 6, 7, 21, 22 and 23 present extremes for temperature and precipitation. The extreme values on these maps are not averages; they are the interpolated coldest and warmest temperatures and maximum precipitation recorded between 1901 and 2000. This long period of record provides more reliable extreme values than a 30-year period of record. The maps do not represent the entire period of record for all stations because some of the station records started prior to 1901.

Using climate information

Farmers are risk managers; their decisions today affect future outcomes. Climate variability is one of the risks they must manage. For instance, when selecting crop types and varieties, they need to assess such aspects as likely fertilizer needs, yield and price potential, and marketability, along with climate.

The climate elements most often used in agricultural decisions are precipitation, sunshine hours, temperature and information derived from temperature, such as degree days and frost dates. Agricultural managers use information on the average conditions as well as the variability in these conditions.

Roger Bryan

Alberta Agriculture, Food and Rural Development

The averages for the climate elements provided in this Atlas show what has happened. This recent history of our climate is our best guide as to the climate conditions that can be expected over the next five to 10 years. Climate elements can also be expressed in terms of the expected ranges or measures of variability. These define what may happen and how often it may occur. By combining knowledge of the agricultural operation with knowledge of what is likely to happen, the agricultural manager can then decide on the acceptable level of risk due to adverse conditions.

Crop producers generally look at the most likely weather conditions rather than the extremes because the key inputs and decisions are made well in advance of achieving results. Severe weather will usually result in reduced yield and/or grade loss, not total crop failure. Crop insurance provides some financial protection from consequences of severe and extreme events.

Most crop varieties common to Alberta are bred to do well over a wide range of climate conditions. In selecting new crop types and varieties, farmers consider climate characteristics like the heat units available, growing season length, frost-free period length and the expected date of fall frost. For example, the yield potential of some crops is closely related to the growing season length or heat units available.

AGRICULTURAL CLIMATE ELEMENTS

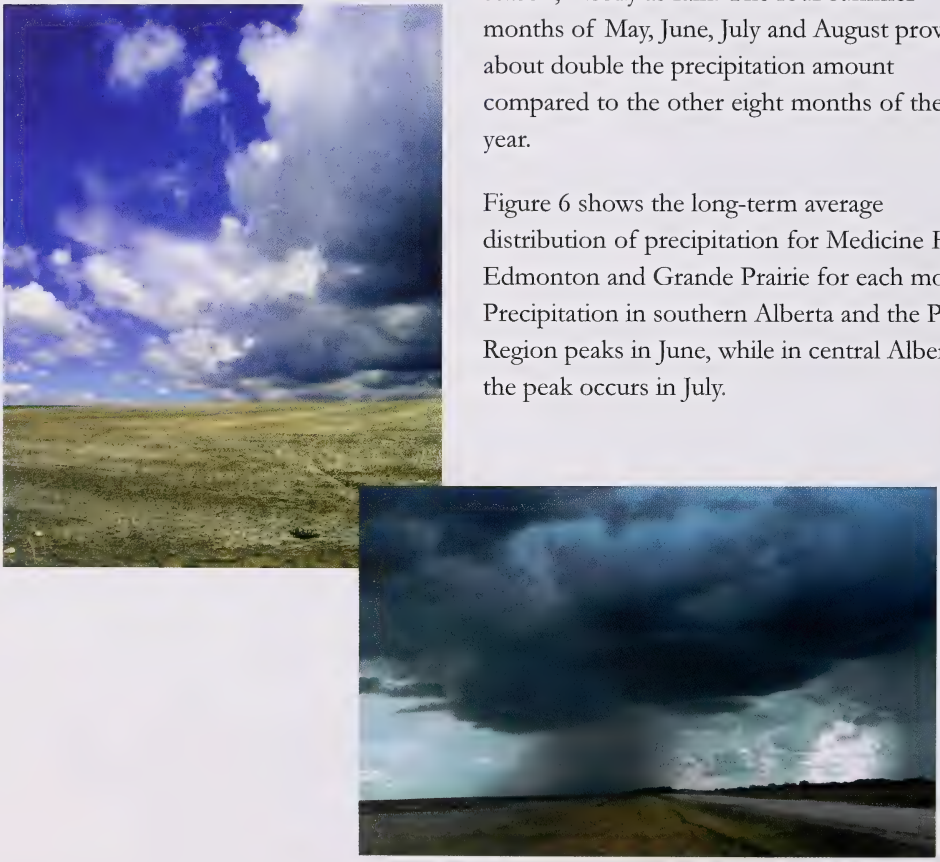
The climate elements that most frequently influence agriculture are precipitation and temperature. These provide the energy for plant growth and the water required for the plant to take full advantage of the energy available. Animals are affected more by extremes of temperature and precipitation than by average conditions.

Precipitation

Precipitation provides the source of all terrestrial water. It occurs in many forms, including rain, snow, dew and hail, but rain and snow are the greatest contributors.

In Alberta, precipitation is not uniformly distributed throughout the year. Generally, in agricultural areas, 50 to 60 per cent of annual precipitation occurs during the growing season, mostly as rain. The four summer months of May, June, July and August provide about double the precipitation amount compared to the other eight months of the year.

Figure 6 shows the long-term average distribution of precipitation for Medicine Hat, Edmonton and Grande Prairie for each month. Precipitation in southern Alberta and the Peace Region peaks in June, while in central Alberta the peak occurs in July.



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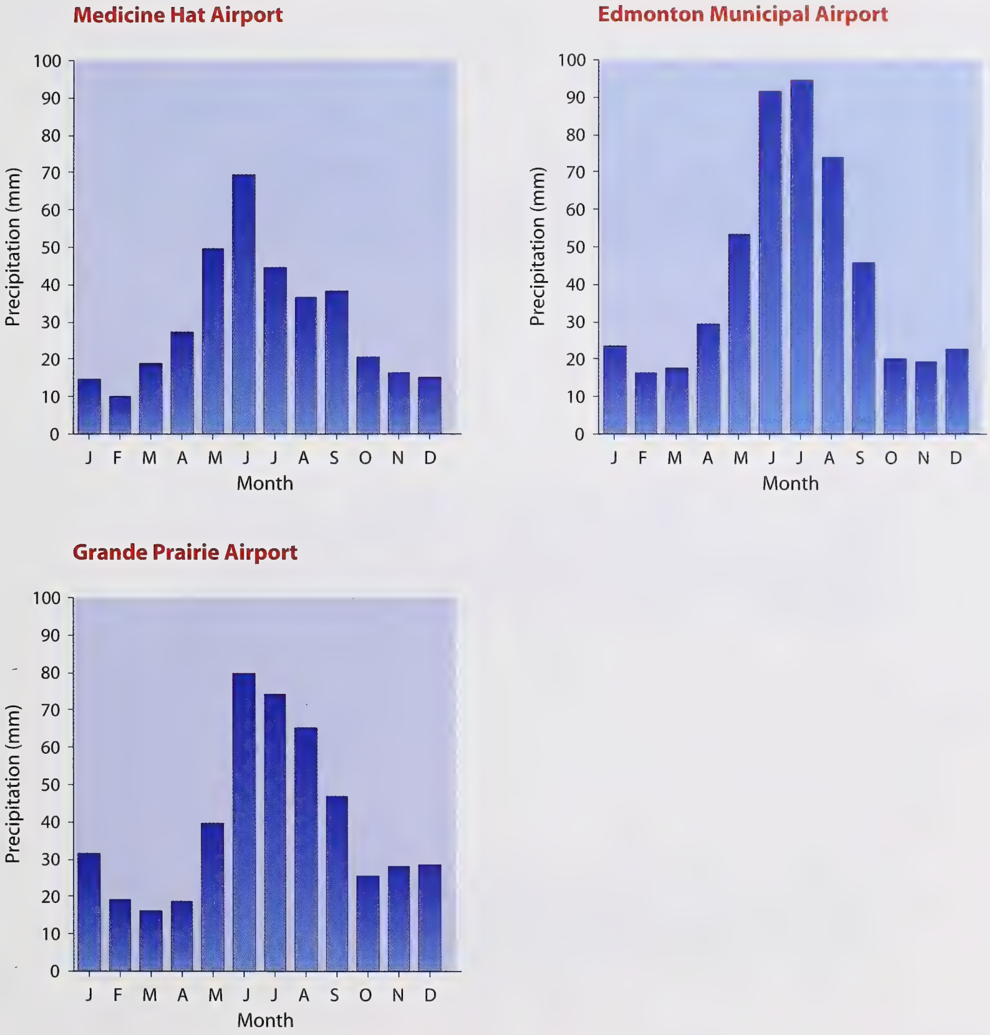


Figure 6. Average monthly precipitation for three Alberta stations, 1971 to 2000

Figure 7 shows precipitation from September 1 to August 31, from 1961 to 2000, for Lethbridge, Edmonton and Grande Prairie. The information is split into overwinter precipitation (September 1 to April 30) and growing season precipitation (May 1 to August 31).

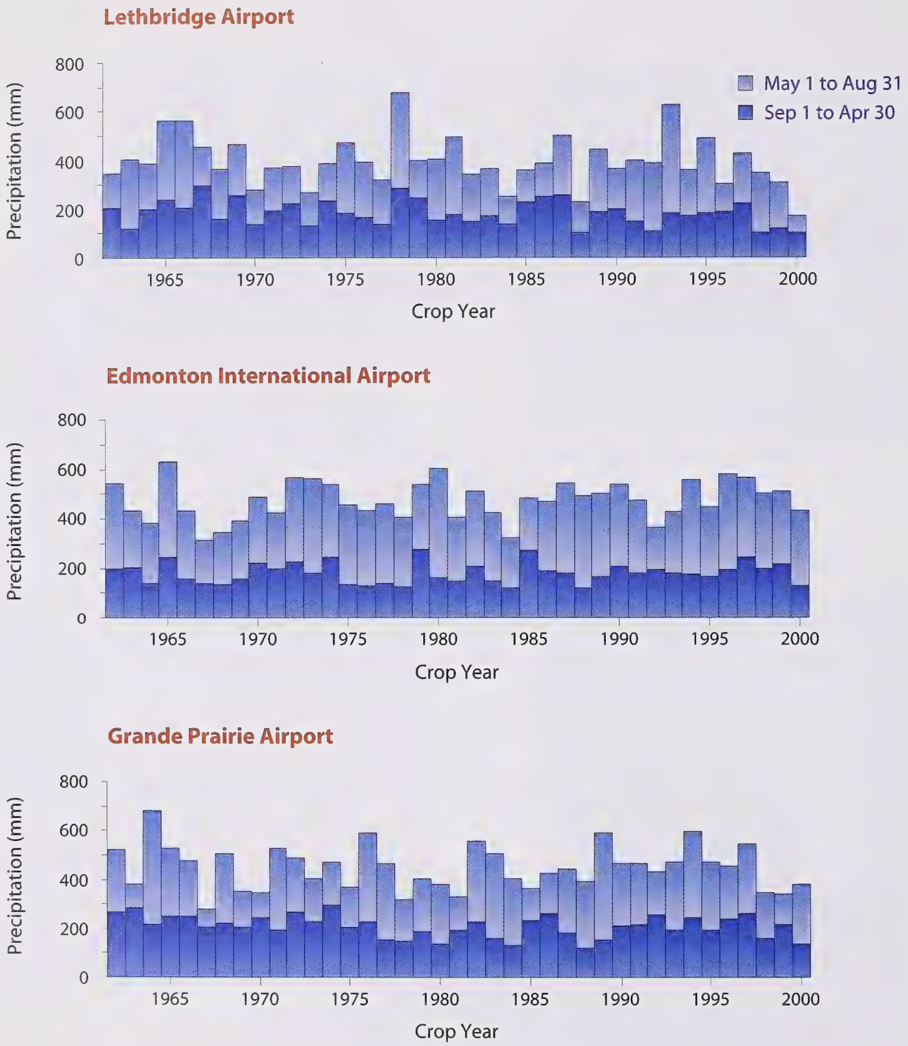


Figure 7. **Annual and growing season precipitation for three Alberta stations, Fall 1961 to Summer 2000**

Precipitation in any month is extremely variable with dry spells of a month or more possible at any time. In general, the variability of precipitation is greater in southern Alberta than in the Peace River Region and central Alberta.

Crop water use generally exceeds precipitation during the growing season in Alberta. Therefore, overwinter precipitation is significant for building up soil moisture reserves for crop production. In the interval between harvest and seeding of annual crops, 25 to 30 per cent of the precipitation is rain, while the rest is snow. (See *Soil moisture conditions in Alberta* for more information on soil moisture reserves.)

Temperature

Temperature affects all living things. Each plant and animal has its own specific optimum temperature for growth and a temperature range over which it thrives. Once temperatures outside this range are encountered, the animal or plant suffers and growth slows. Cool season crops such as wheat, barley and oats do not grow well at temperatures below 5°C. They grow best between 15 and 25°C, and their optimum temperature for growth is about 20 to 22°C, depending on the species. Cool season crops are stressed by temperatures above 30°C. Warm season crops such as corn require temperatures about 5 to 10°C warmer than cool season crops.

In the winter, the average temperature decreases towards the north and with distance from the mountains and the decreasing effect of the chinook. In the summer, the highest elevations have the lowest temperatures, and the influence of latitude is less. The highest temperatures occur where the elevation and precipitation are the least. High areas have lower temperatures than the surrounding lowland area because temperatures drop 1°C for each 100-m rise in elevation.

Heat units

The heat available for agricultural purposes can be expressed in various types of heat units. These include growing degree days, corn heat units, P-days and heating degree days.

Growing degree days

A ***degree day*** is the departure of the average temperature for a day from some reference temperature. ***Growing degree days*** are used to match crop requirements for heat to the amount of heat available. The reference temperature for calculating growing degree days is the minimum threshold temperature at which plant growth starts. For most of the major crops grown in Alberta, the minimum threshold temperatures range from 0 to 5°C (Table 1). For crops like beans and corn, the threshold is 10°C. The upper temperature threshold for most crops grown in Alberta is 30°C; temperatures higher than this upper threshold can damage plants.

Table 1. Minimum threshold temperatures for growth of selected crops and insects

Crop or insect	Minimum threshold temperature (°C)
Wheat	0.0
Barley	0.0
Spinach	2.2
Lettuce	4.4
General plant growth	5.0
Canola	5.0
Forages	5.0
Cabbage maggot	6.0
Potatoes	7.0
Variegated cutworm	7.0
Corn and beans	10.0
Grasshoppers, corn borers	10.0
General insect development	15.0

Adapted from: Ash et al., 1999. Agricultural Climate of Manitoba; and Cao and Moss, 1989. Temperature Effect on Leaf Emergence and Phyllochron in Wheat and Barley.

To calculate the growing degree days for any particular day, the average daily temperature is determined from the maximum and minimum air temperatures. The minimum threshold temperature, 5°C in the following example, is subtracted from the average daily temperature:

Maximum temperature = 27°C
Minimum temperature = 15°C
Average temperature = (27+15) ÷ 2 = 21°C
Degree days above 5°C = 21 - 5 = 16

If the average daily temperature is below the base temperature, the growing degree day value equals zero. Negative values are not calculated because the crop is not set back. The calculation of growing degree days assumes that plant growth is related directly to temperature if there are no other limitations. This is generally true as long as temperatures are not high enough to cause damage to plants. When applying degree days, it is important to know the temperature units (Fahrenheit or Celsius) and the minimum threshold temperature used for the calculation.

Annual degree days are calculated by summing the degree days for each day of each month in the growing season. Degree day climate normals are calculated by averaging the yearly values for the 30-year period. The average annual growing degree days for Alberta are shown on Map 8.

Degree day climate normals permit comparison of areas in terms of their growing potential. For example, two types of canola have quite different degree day requirements. Argentine varieties require 1040 to 1100 degree days, while Polish varieties only require 860 to 920. Looking at the number of degree days available for growth will help in selecting the canola type most suited to an area. For delayed seeding or reseeding, calculating the degree days expected in the remainder of the growing period will help determine which type to plant.

Corn heat units

A more complex calculation is used to determine ***corn heat units*** (CHU), a measure of how heat affects the growth of corn.

Like growing degree days, the daily CHU is calculated from the daily maximum and minimum air temperatures. However, the CHU calculation takes into account that the crop responds differently to daytime and nighttime temperatures. It assumes no growth occurs during the night when temperatures are below 4.4°C and during the day when temperatures are below 10°C. Also the calculation uses 30°C as the optimum daytime temperature because warm season crops develop fastest at 30°C. There is no optimal temperature for night since the nighttime temperature seldom exceeds 25°C. The daily CHU is the average of the daytime and nighttime CHU values. The formulas are as follows:

$$CHU_X = \begin{cases} 1.8\,(T_{min} - 4.4) & \text{if } CHU_X > 0 \\ 0 & \text{if } CHU_X \leq 0 \end{cases}$$

$$CHU_Y = \begin{cases} 3.33\,(T_{max} - 10) - 0.084\,(T_{max} - 10)^2 & \text{if } CHU_Y > 0 \\ 0 & \text{if } CHU_Y \leq 0 \end{cases}$$

$$CHU = (CHU_X + CHU_Y)\,/2$$

where **CHU** = Corn heat units
CHU_X = Nighttime corn heat units
CHU_Y = Daytime corn heat units
T_{max} = Daily maximum temperature (°C)
T_{min} = Daily minimum temperature (°C)

The accumulated CHU is the sum of the daily CHU from a starting date to a season-ending date. The date to start accumulating CHU is estimated as the last day of three consecutive days with mean daily air temperatures greater than or equal to 12.8°C. The threshold temperature of 12.8°C corresponds closely with the average seeding date for grain corn. It also corresponds to the time when sufficient heat has been received to raise the soil temperature to 10°C, which ensures corn germination. The ending date for accumulating CHU is the first fall frost with a minimum temperature equal to or less than -2°C.

The annual total corn heat units for Alberta are shown on Map 9.

P-days

Physiological days for potatoes, called ***P-days,*** are a measure of how heat affects the growth and development of potatoes. Like CHUs and degree days, P-days are calculated using the daily minimum and maximum air temperatures. The calculation of the daily P-day value divides the day into four parts to account for temperature variations. For potatoes, the minimum, optimum, and maximum developmental temperatures are 7°C, 21°C and 30°C, respectively. P-day maps were not calculated for this Atlas.

Heating degree days

Another use of the degree day concept is heating degree days, which indicate the amount of heating required for buildings. Heating degree days, shown on Map 10, are calculated by subtracting the daily average temperature from the base temperature of 18°C. From these values, the energy needed to maintain a comfortable temperature in a building can be estimated. Heating degree days or some other similar unit with a different base temperature could be used to estimate livestock feed requirements.

Frost-free period

The ***frost-free period*** is the number of days between the last date of 0°C in the spring and the first date of 0°C in the fall. It provides a measure of the period during which plant growth should occur uninterrupted by frost, and it provides a way to compare growing conditions within the province.

The frost date is the date when the air temperature drops to 0°C. Air temperature is measured at 1.2 m above the ground surface at weather stations by thermometers inside a Stevenson screen (see *Understanding weather and climate data*). However, the air temperature close to the ground surface, where the crop occurs, is cooler than the temperature at screen height.

A few stations, including five of Agriculture and Agri-Food Canada's weather stations, also record temperatures at 3 or 4 cm above a short-grass surface using thermometers exposed to sunlight. These grass temperatures are more representative of the crop temperature. When frost occurs in late spring and early fall, research shows that the grass minimum temperature is always lower than the temperature at the screen height. The difference varies, but is generally from 2 to 5°C.

Although the screen temperature is used to estimate frost dates, the difference between the air temperature at screen level and at crop level does not generally create large discrepancies in determining the frost-free period for most crops. Grain crops generally freeze at several degrees below 0°C, so a screen temperature of 0°C is a suitable indicator of damaging frost for these crops.

Actual frost damage depends on the temperature, crop type and crop condition. Most of the field crops grown in Alberta can withstand temperatures as low as -2°C without significant damage. Many seedlings can withstand temperatures of -4 to -6°C without harm. This permits spring seeding to start when soil temperatures reach a suitable level, rather than waiting until the last chance of frost passes. The crop stage most susceptible to frost damage is flowering.

The frost date varies from year to year. Within any given area, local conditions may cause a variation in the frost dates by as much as several weeks. The data presented in Figure 8 show that about 50 per cent of the last spring frosts occur in a period of a week before and after the average last frost date. In the fall, the first frost occurs 50 per cent of the time in a period of one week before and about one and a half weeks after the average first frost date. The average frost dates in Alberta are shown on Maps 12 and 13.

The effect of a 100-day frost-free period is not equal across the province because day length varies. The longer day length in the Peace River Region, compared to southern Alberta, partly compensates for the effects of the shorter frost-free period in the north. Each crop reacts differently to increasing day length, so no general adjustment of frost-free periods for day length is possible.

Estimating probable frost dates

Average dates of frost occurrence have often been used for estimating probable freezing dates. However, averages have limited value because they denote the 50 per cent risk level or the probable occurrence of untimely frost in, for example, five out of 10 years. This may well be too much risk for economic viability in the long run.

On the other hand, trying to avoid all frost damage by sticking to a limited number of hardy, short-season crops may not be profitable either. The indirect costs of lost opportunities could be very high. For planning purposes, it may be better to use an intermediate risk level, such as 25 per cent, where the advantages of growing a particular crop outweigh the risks of occasional frost damage.

Probable frost dates can be estimated using the following method:

1. Find the average dates (50 per cent risk level) for the last spring frost and the first fall frost for a location from Table 2 or Table A1 in the Appendix. (Table A1 lists the stations in the agricultural area of Alberta; Table 2 below lists a few selected stations.)
2. Next, use the appropriate curve, either Spring or Fall, on Figure 8 to estimate the freezing date adjustment factor for the desired risk level.
   The Spring curve indicates the probability of the last spring frost occurring after a certain date. The Fall curve indicates the probability of the first fall frost occurring before a certain date. The two curves are derived from long-term minimum temperature records at stations representing the major agricultural regions in Alberta. Estimates from the curves are generally accurate within one or two days for the 15 per cent to 85 per cent probability range.
3. Add the freezing date adjustment factor to the average date for the probable frost date at that risk level.

As an example, spring and fall frost dates at Tofield (50 km southeast of Edmonton) can be estimated for the 25 per cent risk level using this method. The weather station closest to Tofield is Tofield North. From Table 2, the average date for the last spring frost at Tofield North is May 25. Using the Spring curve on the figure and the 25 per cent risk level, the adjustment factor is +9 days. Nine days after May 25 is June 3. Similarly, the average date for the first fall frost at Tofield North is September 14, and the freezing date adjustment factor from the Fall curve is -9 days. Nine days before September 14 is September 5.

Table 2 Frost dates for selected Alberta locations

Station location	Average date of first fall frost	Average date of last spring frost	Frost-free period
Calgary Int'l A	September 14	May 20	117
Edmonton Int'l A	September 13	May 21	115
Grande Prairie A	September 11	May 18	116
Lethbridge A	September 18	May 17	124
Lloydminster A	September 15	May 19	119
Medicine Hat	September 23	May 14	132
Red Deer A	September 12	May 20	115
Tofield North	September 14	May 25	112

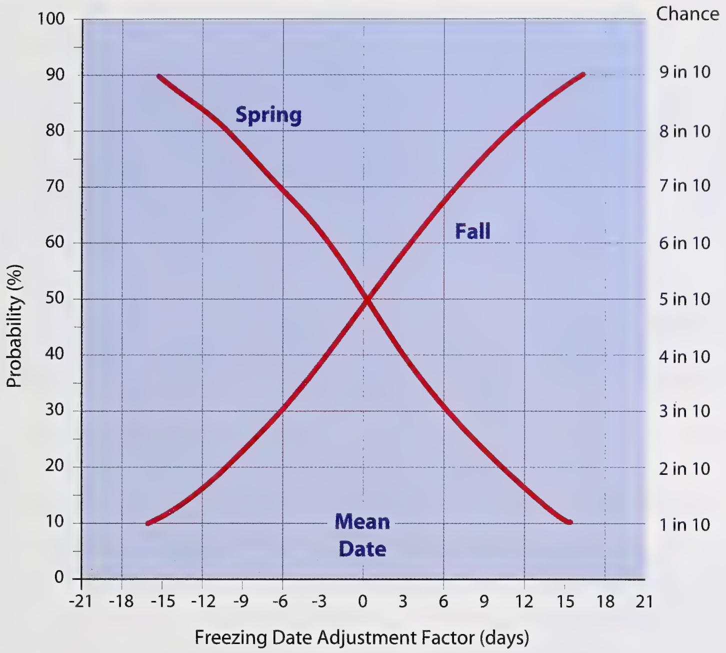


Figure 8. Curves for estimating freezing date adjustment factors

Growing season length

The ***growing season*** is the period of time each year during which perennial crops such as pastures and forages can grow. The growing season is longer than the frost-free period. Plant growth begins whenever air and soil temperatures are above freezing most of the time. When the average daily air temperatures reach 5°C for a 5-day period, daily heat unit accumulations begin.

The start, end and length of the growing season are different every year. The variability in the growing season is similar to that for the frost-free period. Map 14 shows the average starting date, Map 15 shows the average ending date, and Map 16 shows the average length of growing season.

The average length of the growing season can be used to compare growing conditions across the province. Figure 9 shows the average growing season lengths for three stations. Small areas of longer growing season lengths exist in various parts of the province because of local conditions.

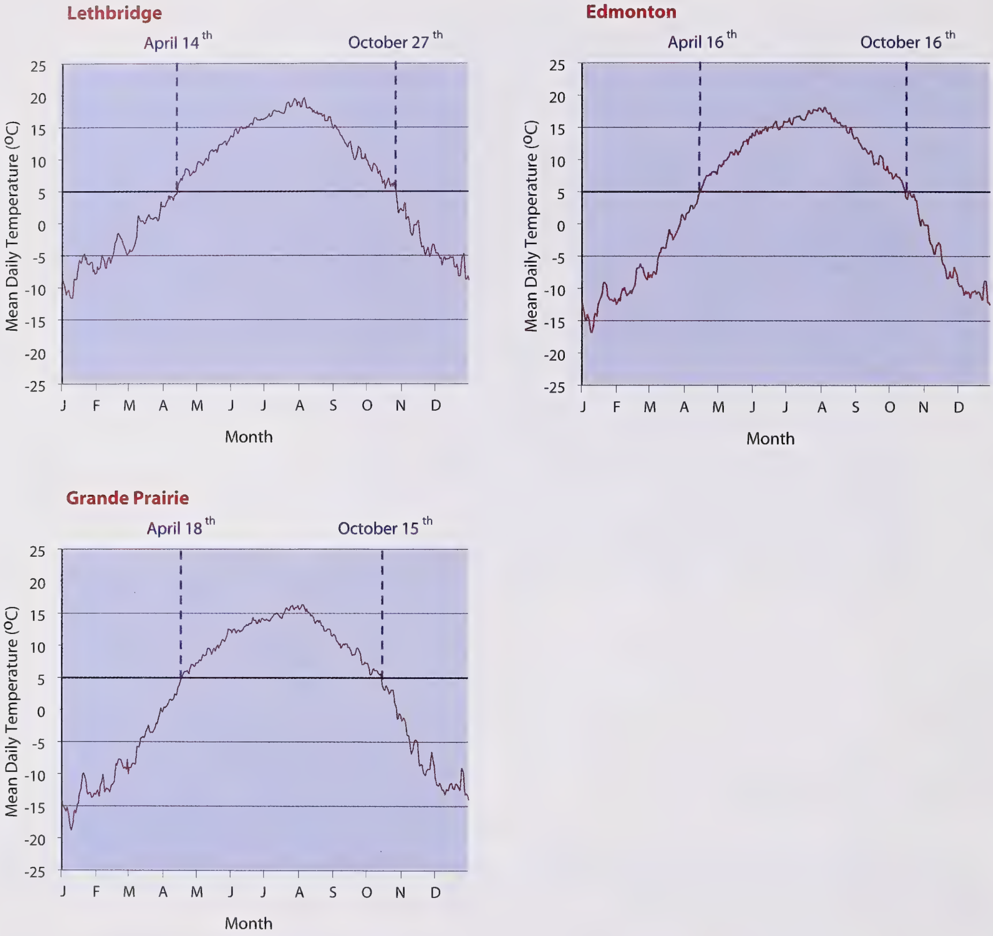


Figure 9. Growing season length for three Alberta areas, 1971 to 2000

As with frost-free period and degree day calculations, the length of the growing season does not account for the effect of longer summer day length in northern Alberta compared to southern Alberta. The longer day length helps compensate for the shorter growing season and lower heat units, making crop production better than might be expected in northern Alberta.

Wind

Wind is an important consideration for agricultural producers. Wind gusts and prevailing wind direction are factors in preventing soil erosion, making effective agricultural chemical applications, managing manure and designing structures. Higher wind gusts and drier conditions also increase the risk of fires getting out of control.

Wind erosion occurs when soil is not adequately covered and when winds are strong enough to move soil particles. Wind erosion reduces soil productivity. Winds can carry soil particles and soil-attached chemicals and nutrients into the air, reducing air quality and visibility. Eroded particles can be deposited in water bodies, reducing water quality.

Maps 17, 18, 19 and 20 show mean wind speeds and wind direction. Lands subject to windy weather require practices to prevent wind erosion, such as reducing or eliminating tillage, and planting field shelterbelts. Areas with frequent high winds may need to be kept under perennial cover. Prevailing wind direction and speed are important factors in designing field and farmstead shelterbelts. For example, where possible, shelterbelts should be planted at right angles to the most common prevailing wind direction.

Wind speed and direction are also important considerations when applying pesticides and fertilizers. For instance, farmers applying agricultural chemicals must check product labels for wind speed limits and should avoid spraying when the wind is blowing toward sensitive areas such as water bodies.

Winds can blow unpleasant odours towards neighbouring residences. Where possible, facilities that generate strong odours should be located downwind of nearby residences, and manure should be spread when the wind is blowing away from residences.

Maximum wind speeds are a factor in the design of buildings and other structures that must withstand high winds. Table 3 lists the average number of days with wind gusts greater than 52 km per hour and 63 km per hour for Lethbridge, Edmonton and Grande Prairie Airports for each month. It also shows the greatest wind gust ever recorded for each month at the three weather stations, including the wind direction and date of the event.

Wind gust speed and direction for three Alberta stations

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
a. Wind gusts for Lethbridge Airport													
Days with wind: 1971 to 2000 average													
Wind speed > 52 km/h	10.1	7.7	6.3	5.4	5.4	5.6	3.7	3.8	4.3	7.6	9.1	11.0	80.0
Wind speed > 63 km/h	5.7	4.3	3.2	2.5	2.0	2.3	1.7	1.2	1.6	4.0	4.3	6.5	39.2
Maximum gusts: 1953 to 2000*													
Maximum wind gust (km/h)	140.0	143.0	138.0	138.0	148.0	137.0	122.0	122.0	124.0	153.0	171.0	148.0	171.0
Date (yyyy/dd)	1964/16	1965/19	1961/01	1961/01	1965/16	1961/30	1964/22	1963/14	1961/03	1965/01	1962/19	1963/23	1962/19
Direction	SW	SW	SW	SW	SW	SW	W	SW	SW	W	W	SW	W
b. Wind gusts for Edmonton International Airport													
Days with wind: 1971 to 2000 average													
Wind speed > 52 km/h	0.8	0.4	0.5	0.9	1.2	1.0	0.3	0.3	0.6	0.9	0.6	0.7	8.2
Wind speed > 63 km/h	0.3	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.2	1.9
Maximum gusts: 1953 to 2000*													
Maximum wind gust (km/h)	105.0	97.0	100.0	106.0	113.0	111.0	111.0	109.0	113.0	146.0	126.0	103.0	146.0
Date (yyyy/dd)	1967/08	1965/19	1965/13	1982/29	1965/16	1985/19	1987/31	1997/27	1967/22	1965/01	1962/24	1967/11	1965/01
Direction	W	N	NW	W	NW	W	W	S	W	NW	NW	NW	NW
c. Wind gusts for Grande Prairie Airport													
Days with wind: 1971 to 2000 average													
Wind speed > 52 km/h	1.4	0.7	0.3	0.9	1.1	0.9	0.4	0.4	0.5	1.7	1.0	0.6	9.9
Wind speed > 63 km/h	0.4	0.2	0.2	0.2	0.3	0.2	0.1	0.1	0.1	0.4	0.3	0.3	2.6
Maximum gusts: 1953 to 2000*													
Maximum wind gust (km/h)	121.0	120.0	105.0	109.0	122.0	105.0	108.0	109.0	120.0	111.0	106.0	104.0	122.0
Date (yyyy/dd)	1972/05	1985/14	1971/07	1961/17	1971/14	1960/01	1973/11	1962/20	1980/30	1982/22	1962/24	1979/05	1971/14
Direction	W	SW	W	W	SW	W	SW	W	W	SW	W	W	SW

* *These stations started to collect hourly wind speed and direction data in 1953.*

Source: Environment Canada, 2003. Canadian Climate Normals for 1971 to 2000.

Soil moisture in agriculture

Soil moisture is ultimately the source of water for crops because virtually all water used by crops is taken from the soil by the root system. Whether the water source is precipitation or irrigation, for practical purposes the water must first enter the soil before the crop can use it.

Since precipitation during the growing season in Alberta is not sufficient to meet crop demand, agriculture relies on water stored in the soil from fall and winter precipitation to supplement what the growing season provides. The soil moisture reserve also provides a steady supply of moisture that allows the crop to grow during moderately dry periods.

The level of soil moisture reserve in the spring is an indicator of risk to crop production. When soil moisture levels are drier than normal, timely above-normal precipitation is required during the growing season to make up the deficit. The chance of this occurring in a growing season is low, which means the risk of below-average crop production increases. When moisture reserves are high, crops can produce normal yields despite below-average precipitation and periodic dry spells, and will generally produce above-average yields if the growing season precipitation amounts are average or better. Therefore, the risk of below-average crop performance is reduced. Droughts occur in Alberta when precipitation is not sufficient to return soil moisture to normal levels, or to meet normal crop demands during the growing season, or both.

Not all moisture in the soil is available for crop growth. Crops can access about half of the total moisture in the soil. The rest is too tightly held within the soil for plants to use. For agricultural purposes, soil moisture refers to the ***plant-available water***. Plant-available water is the fraction of the total soil water available for plant use. It is usually expressed as an amount per depth of soil (e.g. millimetres per metre) for convenient relation to precipitation amounts.

Moisture storage efficiency

Soils vary in their capacity to store soil moisture, with sandy soils having about half the capacity of clay soils (Table 4). Therefore, if the top 120 cm (the root zone) of a sandy soil and a clay soil were both completely filled with soil moisture, the clay soil would be able to supply over 200 mm of plant-available water, whereas the sandy soil would provide only about 100 mm. This means that risk of poor crop performance due to water shortage is higher on sandy soils than on clay soils.

Table 4 Plant-available water holding capacity for soil textural classes

Soil textural class	Soil moisture holding capacity in a 120 cm root zone (mm)
Sand, loamy sand	100 - 120
Sandy loam	150
Loam, silt loam, silt	200
Clay loam, sandy clay loam, silty clay loam	220
Sandy clay, silty clay, clay	200

Adapted from: Brown and Carlson, 1990. Grain Yields Related to Stored Soil Water and Growing Season Rainfall.

Mapping soil moisture

Alberta Agriculture, Food and Rural Development samples and maps soil moisture as part of an effort to monitor the risk of agricultural drought. Annual fall soil moisture maps were produced from 1982 to 1994, and then were reinitiated in 2001. Preparation of annual spring soil moisture maps began in 1988 and is ongoing.

The maps describe the conditions for medium textured soils on annually cropped land (stubble fields), with irrigated land excluded. They are based on a set of 250 to 300 representative fields. Soil samples are taken to a depth of 100 cm in each field during October for the fall maps and during April for the spring maps.

Soil moisture varies from one part of a field to another, and locations a few metres apart can have considerable differences in moisture levels. Differences are caused by uneven snow cover, variable patterns of snowmelt and runoff, and variation in precipitation, topography, cropping patterns, land management, and soil properties such as texture. Even small surface depressions, not noticeable when fields are dry, can hold considerable water during snowmelt. It is difficult to characterize the moisture content of a field using a single moisture content; therefore, the maps are based on ranges of moisture content.

Annual soil moisture levels are classified as Very Low, Low, Medium, or High, which correspond to ranges of 0 to 25, 25 to 75, 75 to 125 and over 125 mm of plant-available water, respectively. To assess long-term trends, average soil moisture levels for spring and fall are determined based on the midpoint of each range.

Spring soil moisture is an indicator of risk for successful cropping in the upcoming growing season. Lower than average soil moisture levels mean that crops are more dependent on the right amounts and timing of growing season precipitation, and the risk of poor crop performance from water stress increases. Above-average soil moisture levels mean that crops can survive short or moderate dry periods during the growing season, and the potential for average or better crop performance increases.

Figure 10 shows the average spring soil moisture levels from 1988 to 2002. The driest springs occur in an area east of Calgary to Medicine Hat and Coronation (165 km east of Red Deer). A large portion of eastern Alberta and part of the central Peace Region have spring moisture levels as dry as those in the Lethbridge - Medicine Hat area.

Annual re-cropping would be successful in most areas of Alberta if 100 mm of soil moisture could be stored by May 1, given normal growing season precipitation. In the drier areas of Alberta, overwinter precipitation is not always sufficient to provide enough soil moisture for successful re-cropping. In areas where irrigation is not available, one management option is to not plant a crop (summerfallow) in alternate years. The non-cropping season is extended to about 20 months from about eight, and this is usually long enough to provide sufficient soil moisture to successfully produce a crop.

Crop residue management practices to conserve soil moisture are key to crop production in low moisture areas. Such practices include reduced or zero tillage and snow trapping. Managing crop rotations to optimize the crop's use of soil moisture and ***flexcropping*** (basing the decision to seed or summerfallow on spring soil moisture levels) are other options for managing crops under limited moisture conditions.

Figure 11 shows the per cent of years from 1988 to 2002 in which 100 mm of plant-available water was observed in the soil in the spring. South central Alberta, from Calgary to Medicine Hat and north to Coronation, has the lowest probability of 100 mm of spring soil moisture. Other low areas include pockets in the northeast portion of the agricultural area and in the central Peace Region. Much of southwest and west central Alberta can expect 100 mm of spring soil moisture at least 80 per cent of the time.

Fall soil moisture is an indicator of potential shortages of livestock water supply, because livestock are often watered from dugouts, which are refilled by runoff from snowmelt. Dry conditions prior to winter tend to decrease snowmelt runoff, because the snowmelt will more likely infiltrate into the soil than flow as runoff into a dugout. Fall soil moisture is typically lower than spring soil moisture in Alberta.

Figure 12 shows the average fall soil moisture levels from 1982 to 1994. The driest area extends from east of Calgary to the southeast corner of the province and north to Provost (about 240 km east of Red Deer). The wettest area is west central Alberta, with a small pocket west of Red Deer having the highest moisture levels. Most areas in the northeast portion of Alberta's agricultural area and in the Peace Region have fall soil moisture levels as low as those near Lethbridge.

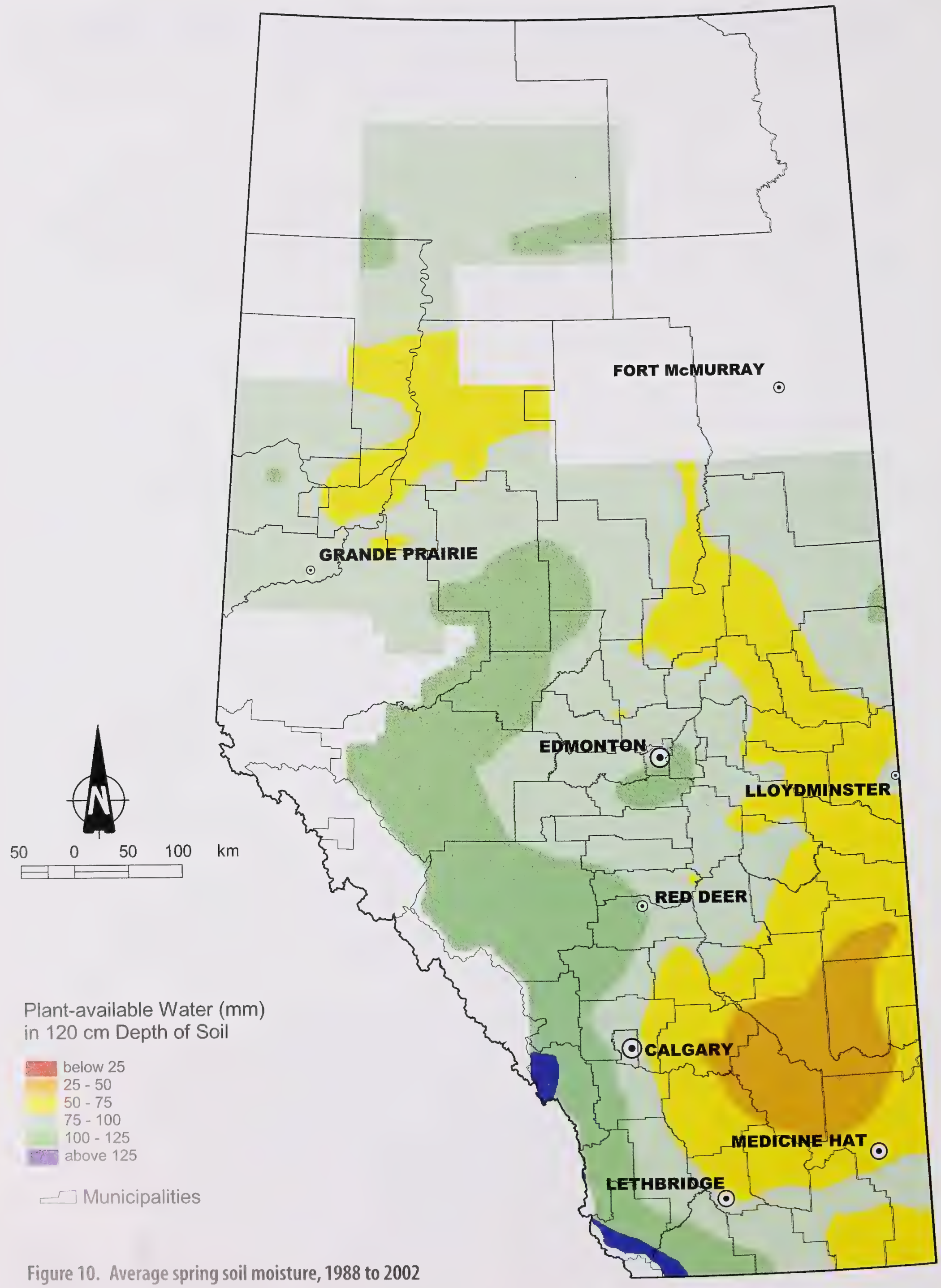


Figure 10. Average spring soil moisture, 1988 to 2002

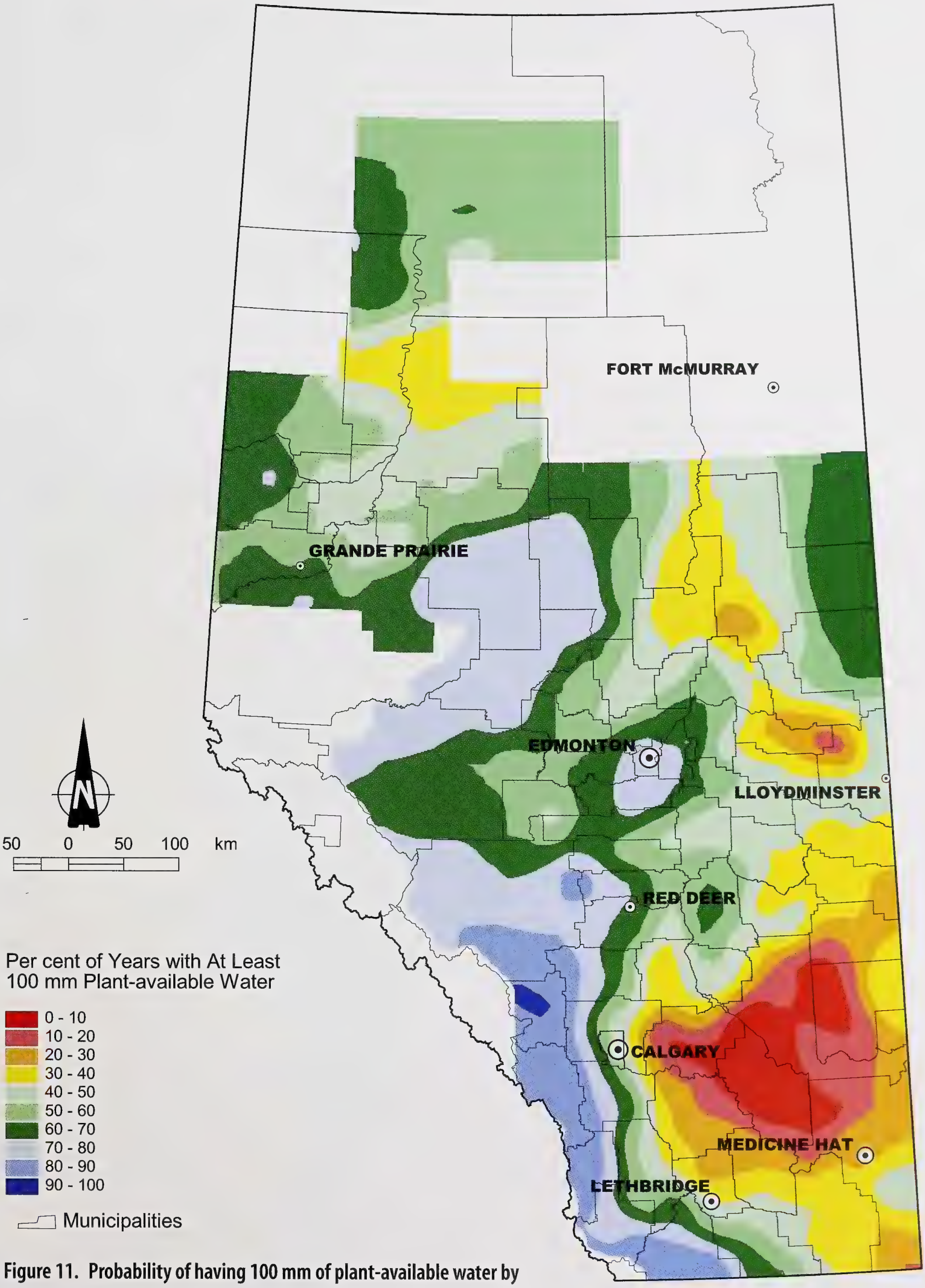


Figure 11. **Probability of having 100 mm of plant-available water by May 1, 1988 to 2002**

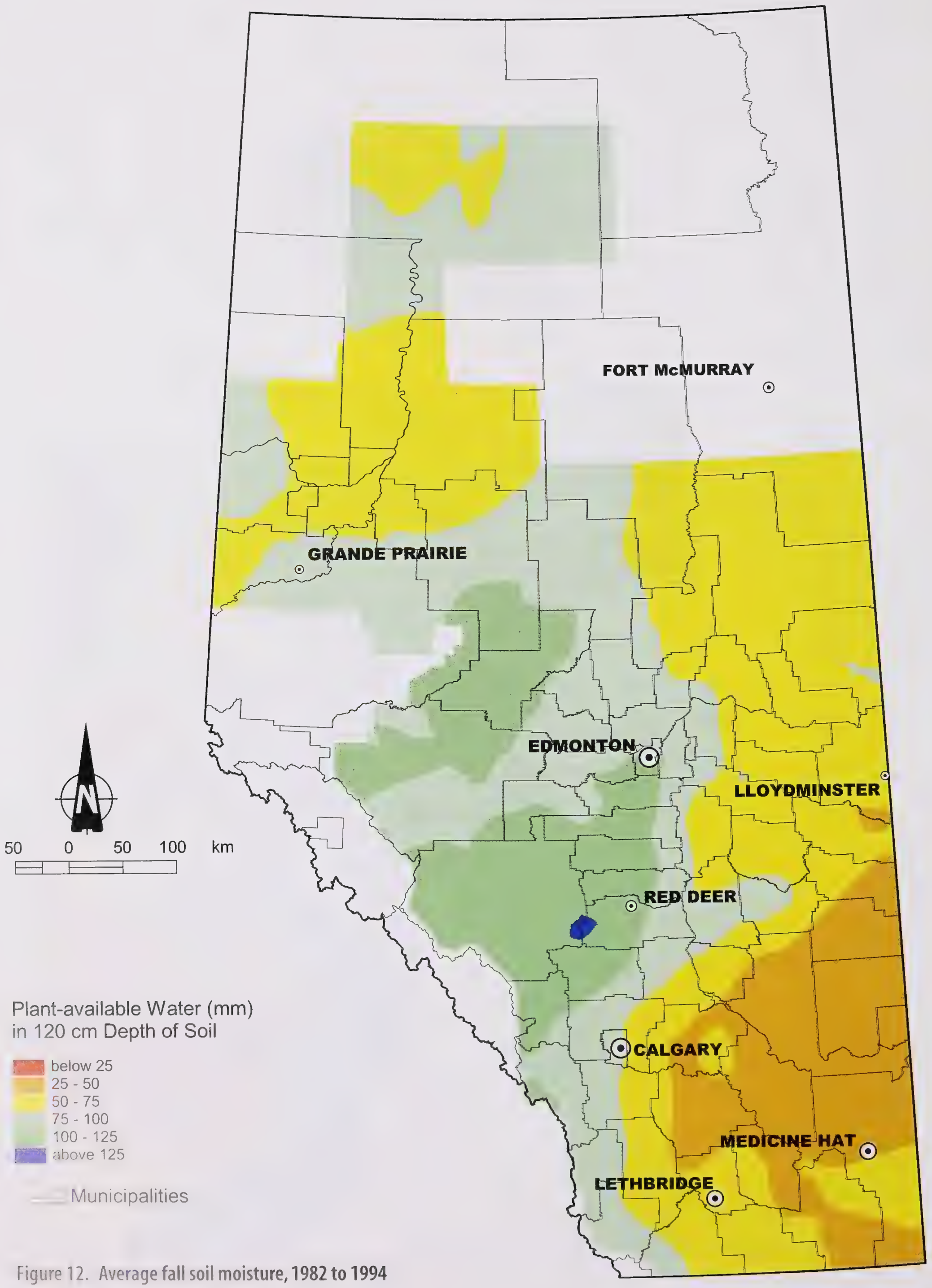


Figure 12. Average fall soil moisture, 1982 to 1994

SOILS AND ECOREGIONS IN ALBERTA

Soil properties are strongly influenced by climate. They are also affected by other ecoregion factors, such as physiography, vegetation, water and land-use.

Both climate and soils data are essential for making many agricultural decisions. For example, the local climatic conditions may be appropriate for a certain crop type, but perhaps the soil has a low moisture-holding capacity that would limit the yield of this crop type.

This chapter provides a general guide to understanding Alberta's agricultural soils to complement the climate information provided in the Atlas. This general understanding creates a foundation for using the more detailed soils information required when making decisions for a specific farm.

Detailed soil survey information for the agricultural region of Alberta is available in digital format in AGRASID (Agricultural Region of Alberta Soil Inventory Database; scale 1:100,000). For information on AGRASID, go to the Alberta Agriculture website: http://www.agric.gov.ab.ca/asic.

Soil-forming factors

Soils are vital to support and sustain crop, range and woodland production as well as to maintain or enhance environmental quality. Soils serve as a medium for plant growth, in the regulation of water supply, in recycling of wastes, as a habitat for organisms and as a support for human infrastructure.

Soils are dynamic and evolve over long periods. Factors controlling the formation of soils include climate, vegetation, parent material, topography and time. Human activities, such as soil management, may also be considered a soil-forming factor.

Climate and associated vegetation play a significant role in soil formation. Differences in climate (especially precipitation and temperature) and associated native vegetation are reflected in different ecoregions (see Figure 4).

Moving from southeast to northwest Alberta, the available moisture generally increases and the temperature generally decreases, resulting in a change in associated vegetation.

The Mixed Grassland ecoregion, in the southeast corner, is characterized by a semiarid climate and short grass prairie native vegetation. As you proceed north and west, the increased moisture results in more vigorous growth of grasses in the Moist Mixed Grassland and Fescue Grassland ecoregions. Farther north and west, fescue grasslands interspersed with aspen groves typify the Aspen Parkland. Proceeding farther north, the Boreal Transition is characterized by a deciduous and coniferous forest. The Peace Lowland is characterized by grassland and forest vegetation.

The colour and depths of the upper soil layers reflect climate, vegetation and organic matter accumulation. In the grassland areas, organic matter has been added to the soil mainly through plant roots, resulting in upper soil layers high in organic matter. In the Mixed Grassland, brown surface colours occur in association with short grass vegetation in a dry climate. The darker brown and black colours of the Moist Mixed Grassland and Aspen Parkland occur with the higher organic matter content from the thicker stands of grasses in more humid areas. In forested areas, organic matter is added as a surface deposit of leaves and needles, resulting in leached upper soil layers low in organic matter and light gray in colour.

Parent material is the unconsolidated material in which soils develop. Parent materials were deposited through the actions of ice, wind, water or gravity. For example, materials deposited by glacial ice are referred to as ***glacial till***; gravels, sands and silts deposited by moving water are ***fluvial*** deposits; sand or silt deposited by wind are ***eolian*** deposits; and materials moved by water and deposited in lakes are referred to as ***lacustrine*** deposits.

Properties of soil such as texture and mineral elements are inherited from the parent materials. Most of the soils in central Alberta have developed on glacial till, while most of the soils in the Peace Lowland region have developed on ***glaciolacustrine*** material (deposited from glacial lakes). Till is generally medium textured (loam). Coarse textured soils (sands) are generally associated with fluvial or eolian deposits. Finer textured soils (clays) are generally associated with lacustrine or glaciolacustrine deposits.

Topographic factors, such as elevation and slope aspect, affect soil-forming factors like moisture and vegetation, resulting in different types of soil. The shape of the landscape affects drainage patterns that in turn affect the type and amount of vegetation. Generally, soil is driest on knolls and wettest in depressions. North-facing slopes are usually cooler and moister than south-facing slopes.

Management practices such as crop rotations and tillage methods can influence soil formation. Crop rotations that incorporate forages as well as annual crops in conjunction with reduced tillage increase the amount of soil organic matter. The increased organic matter content alters the soil's physical properties like aggregation and infiltration in the upper soil layers.

Soil profiles

The combined effects of soil-forming factors result in the formation of horizontal soil layers, called ***soil horizons***. The soil horizons extend from the soil surface to the unaltered parent material. The succession of soil horizons is referred to as a ***soil profile***. Usually the soil profile is described to a depth of 1 m.

Different horizons develop as a result of additions (organic matter from plants and animals, water), transfers within the soil profile (leaching, loss of nutrients, movement of materials such as clay, organic compounds or minerals) and transformations (through chemical and biological reactions).

Soil horizons are identified as either mineral or organic. The three main ***mineral horizons*** are A, B and C. The A horizon is at or near the surface and usually has the most organic matter accumulation. The B horizon is below the A horizon. It usually has an enrichment or alteration of some materials, such as clay, and has more structure than the A horizon. The C horizon, closest to the parent material, is relatively unaffected by soil-forming processes. However, calcium carbonates (lime) and salts can accumulate in this horizon.

The three main ***organic horizons*** are referred to as L, F, and H layers, also known as the leaf layers. The L-F-H layers occur in forest soils, at the surface of mineral horizons. They are the accumulation of leaves, twigs and woody materials at various stages of decomposition.

Dominant soils within Alberta's ecoregions

Soil classification or identification is based on the soil profile and its sequence of soil horizons. Soil orders, such as Chernozemic, Luvisolic, Gleysolic and Regosolic, are identified based on the effects of the dominant soil-forming processes or factors.

The Mixed Grassland is dominated by Brown Chernozemic soils, the Moist Mixed Grassland by Dark Brown Chernozems, and the Fescue Grassland and Aspen Parkland by Black Chernozems. Chernozemic soils, typical of grassland soils, are well to imperfectly drained. Soil profiles have brown to black A horizons with brownish B horizons and are underlain by light-coloured C horizons with lime accumulations. Depth to lime is a reflection of moisture penetration. Lime is generally present at 100 to 120 cm deep in central and northern Alberta, while in southern Alberta lime is present at 30 to 40 cm deep.

The Boreal Transition ecoregion is dominated by Luvisols, which are forest soils. These soils are developed under the influence of forest vegetation and are well to imperfectly drained. Soil profiles have a leached, light grayish A horizon and a B horizon enriched with clay. Chernozems and Luvisols dominate the Peace Lowland ecoregion.

Other soil orders can occur in association with Chernozems and Luvisols in the landscape. For example, Gleysols are soils that are poorly drained at some time of the year. These soils often occur in depressions or at lower slope positions. Solonetzic soils are commonly associated with Chernozems through east central Alberta. These soils are well to imperfectly drained and developed on saline parent materials. They are characterized by having a dense impermeable B horizon that limits both water penetration and root development. Regosolic soils are well to imperfectly drained and are considered young soils due to their development. Soil profiles of this order do not have a B horizon and have a thin or no A horizon; usually only the C horizon is present.

Soil use

Alberta has 30 per cent of the arable land in Canada. The three Prairie Provinces account for 80 per cent of the agricultural land base of Canada.

According to the 1996 Census of Agriculture, the proportion of total Alberta farmland that was cultivated varied from 52 per cent in the Moist Mixed Grassland and 54 per cent in the Aspen Parkland, to only 24 per cent in the Boreal Transition. Nearly 37 per cent of the total farmland in the Mixed Grassland and 45 per cent in the Peace Lowland was cultivated. Only a small portion of soils outside the agricultural area is cultivated.

In the 1996 Census, the total number of farms in Alberta was close to 58,000, and the total land area of farms was greater than 20 million hectares. Of the total area farmed, 46 per cent was in crops, 6 per cent in summerfallow, and 42 per cent in natural or seeded pasture. The remaining 6 per cent was in a wide variety of uses such as farmyards, gardens, greenhouses, Christmas trees, woodlots, and wetlands. Cultivated land is dominated by the production of cereal crops, especially wheat and barley. However, the area planted to oilseeds, forages and pulse crops is increasing.

Nearly four times as many hectares of summerfallow occurred in the Mixed Grassland and Moist Mixed Grassland, where soil moisture is relatively low, compared to the summerfallow hectares in the Aspen Parkland, Boreal Transition and Peace Lowland where soil moisture is higher. In contrast, the Aspen Parkland, Boreal Transition and Peace Lowland had nearly eight times the area in hay and forage as the Mixed Grassland and Moist Mixed Grassland ecoregions.

Discussion of maps

Map 1 – Annual total precipitation, 1971 to 2000

Annual total precipitation includes rain, snow and other forms of moisture such as hail. The long-term average annual precipitation in Alberta varies from a low of below 350 mm in the southeast to more than 600 mm in the mountains. Annual precipitation is greatest in the mountains and decreases as the elevation gets lower. The effect of elevation has been estimated as 35 mm for each 100 m of elevation change. The effect of elevation change on precipitation can be seen in areas such as the Cypress Hills, Clear Hills and Swan Hills (see Figure 1).

Map 2 – May 1 to August 31 total precipitation, 1971 to 2000

Precipitation from May 1 to August 31 varies from slightly below 200 mm in the driest prairie areas to more than 325 mm in the mountains, foothills and Swan Hills (see Figure 1).

Precipitation in this period provides most of the water needed for successful crop production. About 60 per cent of the variation in crop yield can be explained by the variation in May 1 to August 31 precipitation. With good growing conditions and proper management, about 100 mm of moisture is required for wheat or barley to mature enough to produce grain; then each additional 25 mm of water will produce 400 to 450 kg/ha of grain (6 to 7 bu/ac of wheat or 7.5 to 9 bu/ac of barley). Wheat and barley require at least 400 mm to reach maximum yield (Campbell et al., 1988). Since the growing season precipitation is usually well short of that amount, moisture stored in the soil from precipitation during the non-growing season becomes a vital supplement. The stored moisture is even more important when growing season precipitation is below normal.

Map 3 – September 1 to April 30 total precipitation, 1971 to 2000

Precipitation in this eight-month period ranges from less than 150 mm in the driest prairie region to more than 275 mm in the mountains. In general, less precipitation is received during this period than in the May to August period shown on Map 2. This precipitation is a mixture of rain and snow. Most agricultural areas receive between 50 and 70 mm of rain, with the balance as snow. The precipitation that is received in the fall before the ground freezes is one of three sources of recharge for the soil moisture reserves between growing seasons. Other moisture sources include melt from winter snow packs and spring rain and snowstorms. In the prairies, spring rain and snowstorms often result in the biggest soil moisture gains between September 1 and April 30.

Map 4 – January daily mean temperature, 1971 to 2000

Average January temperature varies from warmer than -10°C in the foothills and Rockies to colder than -24°C in the far north. The strong north-south trend in temperatures due to the effect of latitude is somewhat modified by the effect of the mountains. Warm chinook winds can increase January temperatures by up to 30°C over a short period of time. The effect of chinook winds is greatest in southern Alberta along the foothills (see Figure 3).

Map 5 – July daily mean temperature, 1971 to 2000

Average temperatures in July range from warmer than 18°C in the southeast to cooler than 13°C in the mountains. The east-west pattern in the summer is markedly different from the north-south latitudinal effect evident in Map 4. In July, dry areas with little cloud cover are subject to greater solar heating. This condition is common in the southeast corner of the province, which experiences the warmest average July temperatures. Areas of high elevation tend to be cooler. Elevation and cloud cover contribute to an east-west temperature gradient in the southern half of Alberta. The eastern half of the Peace Region is generally warmer in July than the surrounding areas.

Surface moisture conditions influence air temperatures. When the surface is dry, solar energy heats the ground, which in turn heats the air above it (called ***sensible heat*** because we can feel it) and contributes to higher air temperatures. When the surface is moist, such as a moist soil, healthy crop or water body, solar energy evaporates water, and the energy is stored as ***latent heat*** which is released when the water condenses to form clouds and precipitation.

Map 6 – Extreme minimum temperature, 1901 to 2000

The coldest temperatures recorded in Alberta range from -46°C in the south to colder than -54°C in the north. This map is based on the 1901 to 2000 period using temperature records available at each station. It does not represent the entire period of record for all stations because some of the station records started prior to 1901; colder temperatures may have occurred prior to 1901. The chinook effect along the Rockies overrides the influence of latitude on extreme minimum temperatures.

Map 7 – Extreme maximum temperature, 1901 to 2000

The hottest temperatures recorded in Alberta vary from more than 40°C in southeast Alberta to less than 32°C in the mountains. The highest extreme maximum temperatures occur in southeast Alberta. The area north of the Battle River (see Figure 1) and the northeast corner of Alberta have higher extreme maximum temperatures than the surrounding areas. Lower elevations and drier soils contribute to higher temperatures. Plants suffer from heat stress when temperatures exceed 30°C for a period of time.

This map is based on temperatures recorded between 1901 and 2000. It does not represent the entire period of record for all stations because some of the station records started prior to 1901; warmer temperatures may have occurred prior to 1901.

Map 8 – Annual total degree days above 5°C, 1971 to 2000

The growing degree days above 5°C vary from a high of 1963 at Medicine Hat Airport to less than 1200 outside of the major agricultural areas. The Peace River Region has higher degree days than the surrounding areas. For example, Grande Prairie Airport has an annual degree day total of 1337. This allows agricultural managers to grow crops and raise livestock in this northern region.

The distribution shown on this map is very similar to the distribution of July daily mean temperatures (Map 5). Since July is one of the warmest months of the year in Alberta, the similar pattern is an indication of the strong link between July daily mean temperatures and growing degree days.

Map 9 – Annual total corn heat units, 1971 to 2000

The corn heat units vary from a high of 2544 in Medicine Hat Airport to less than 1600 outside of the major agricultural areas. The greatest corn production occurs in southern Alberta; however new corn varieties allow producers to successfully grow corn in central regions and as far north as the Peace Region (see Figure 1).

Map 10 – Annual total degree days below 18°C, 1971 to 2000

Degree days below 18°C are used to estimate the energy needed to maintain a comfortable temperature in a building. Annual total degree days below 18°C vary from less than 5000 in southern Alberta to more than 7500 in the northern part of the province. Annual total degree days below 18°C increase with both latitude and elevation in Alberta.

The distribution shown on this map is very similar to the distribution of January daily mean temperatures (Map 4). Since January is one of the coldest months of the year in Alberta, the similar pattern is an indication of the strong link between January daily mean temperatures and heating degree days.

Map 11 – Frost-free period, 1971 to 2000

The frost-free period is the number of days between the date of the last spring frost and the date of the first fall frost. Frost-free periods in Alberta vary from more than 125 days to less than 85 days in non-agricultural areas. The frost-free period can be about a month longer in southern Alberta compared to the rest of the province. Areas of higher elevation have shorter frost-free periods.

Map 12 – Date of last spring frost (0°C), 1971 to 2000

The date of the last spring frost is the date after which the spring daily minimum temperature remains above 0°C. Most agricultural areas of Alberta are frost-free by June 1. The southeast is frost-free earliest, and the north is frost-free only a few days to weeks later. However, frost may occur into July in agricultural areas in some years. Frost can occur in the mountain and foothills regions any time in the summer, especially at higher elevations.

Map 13 – Date of first fall frost (0°C), 1971 to 2000

The date of the first fall frost is when the fall daily minimum temperature drops below 0°C for the first time. The average first fall frost date occurs between September 11 and 20 in most of the province's agricultural areas. However, in some years, the first fall frost may occur in August in the agricultural region. Reports of frost before September 1 are common in non-agricultural areas and the mountains.

Map 14 – Start of growing season (≥ 5°C), 1971 to 2000

Based on an average daily temperature of 5°C or higher for five consecutive days, growth of perennial crops starts before April 17 in southern Alberta and by April 24 in the agricultural areas of northern Alberta. Outside of the agricultural areas in northern Alberta and in the mountain areas, the growing season may start later than May 1.

Map 15 – End of growing season (< 5°C), 1971 to 2000

Based on an average daily temperature of less than 5°C after July 1, the end of plant growth will be later than October 21 in southern Alberta and between October 1 and 21 in the other agricultural areas of Alberta. In parts of the mountains and in extreme northern areas the growing season may end earlier.

The growing season in the Peace Region extends later into the fall than in the surrounding areas. In the Peace Region towards the end of the growing season, the 30-year daily mean temperature normals suddenly dip below 5°C, then immediately bounce back above 5°C for another 5 to 7 days, and then drop below 5°C for the rest of the winter.

Map 16 – Length of growing season (≥ 5°C), 1971 to 2000

The growing season is the number of days between the start of the growing season and the end of the growing season. The growing season period is based on an average daily temperature of at least 5°C. It varies from more than 185 days in southern Alberta to less than 160 days in northern Alberta and the mountain areas.

Map 17 – Mean wind speed and prevailing direction (December, January and February), 1971 to 2000

The prevailing wind direction during the winter is from west to east in most of Alberta. An exception is in the far north of Alberta where cold, dry air from the continental polar and arctic air masses blows from the north to south.

Mean wind speed varies from more than 20 km per hour in the southwest corner of Alberta to less than 8 km per hour farther north and in the mountains. Chinook winds along the foothills of the Rocky Mountains have their greatest effect in the southwest corner of the province (see Figure 3).

Map 18 – Mean wind speed and prevailing direction (March, April and May), 1971 to 2000

The prevailing wind direction in the spring is from southwest to northeast in most of Alberta. An exception is in the far north of Alberta where cold, dry air from the continental polar and arctic air masses blows from southeast to northwest.

Mean wind speed varies from between 18 and 20 km per hour in the southwest corner of Alberta to less than 8 km per hour in the mountains.

Map 19 – Mean wind speed and prevailing direction (June, July and August), 1971 to 2000

The prevailing wind direction during the summer is from west to east in most of Alberta. An exception is in the far north of Alberta where cold, dry air from the continental polar air mass blows from the north to south. Maritime polar air creates a southwest flow in the summer. It is not uncommon for winds to reverse from east to west as a result of maritime tropical air masses.

Mean wind speed varies from between 16 and 18 km per hour in the southwest corner of Alberta to less than 8 km per hour farther north and in the mountains.

Map 20 – Mean wind speed and prevailing direction (September, October and November), 1971 to 2000

The prevailing wind direction in the fall is from west to east or from southwest to northeast in most of Alberta. The exceptions are in the northern part of the Peace River Region (see Figure 1) where winds blow from north to south and the far northeast corner of Alberta where the winds blow from south to north.

Mean wind speed varies from more than 20 km per hour in the southwest corner of Alberta to less than 8 km per hour farther north

Map 21 – Coldest July temperature, 1901 to 2000

The coldest temperatures recorded in July range from less than -6°C in the north to greater than 2°C in southeast corner. This map is based on records from 1901 to 2000. It does not represent the entire period of record for all stations because some of the station records started prior to 1901; colder temperatures may have occurred prior to 1901.

Map 22 – Warmest January temperature, 1901 to 2000

The warmest temperatures recorded in January range from more than 16°C in parts of southern Alberta to less than 10°C in the northeast corner of Alberta. The chinook effect along the Rockies reduces the influence of latitude on minimum temperatures during the winter.

This map is based on records from 1901 to 2000. It does not represent the entire period of record for all stations because some of the station records started prior to 1901; warmer temperatures may have occurred prior to 1901.

Map 23 – Greatest daily precipitation, 1901 to 2000

The greatest or extreme daily precipitation total can exceed 120 mm, especially in the mountain areas. Most regions of Alberta received more than 80 mm of precipitation in one day at least once during the 1901 to 2000 period. Storms usually occur over a two- to three-day period, resulting in even greater totals and reaching up to 275 mm in the mountains. Precipitation intensity, duration and frequency combined with soil properties and management practices influence the risk of soil erosion.

The patchwork appearance of this map is because precipitation by nature has a high degree of variability, especially during the summer months.

Map 24 – Mean annual maximum daily precipitation, 1971 to 2000

The average annual maximum daily precipitation total is the highest amount of precipitation received during the year, averaged over 30 years. The highest average precipitation totals can exceed 45 mm in parts of Alberta. The western half of Alberta receives more precipitation than the eastern half. Storms usually occur over a two- to three-day period, resulting in higher totals.

Map 25 – Annual total global solar radiation, 1971 to 2000

The northern parts of Alberta receive less energy from the sun than the southern parts (see Figure 2). Southern Alberta receives the greatest amount of annual global solar radiation (more than 4800 megajoules per square metre). This amount gradually decreases farther north to less than 4200 megajoules per square metre.

Differences in the amount of cloud cover are likely affecting the pattern seen on this map, with heavier cloud cover in the mountains reducing the amount of solar radiation received there. In addition, very few Alberta stations collect solar radiation data, which can make the interpolated pattern less reliable (see *Interpolation of climate station data* for more information).

Map 26 – Annual number of hot days (> 30°C), 1971 to 2000

On average, the southeast corner of Alberta receives maximum daily temperatures hotter than 30°C between 10 and 20 times in a year, with some areas having even more days than 20 days. Medicine Hat receives an average of 23.6 days exceeding 30°C, including about 17.5 hot days in July and August. The number of days with temperatures higher than 30°C decreases as one goes farther north and west.

Map 27 – Annual number of cold days (< -30°C), 1971 to 2000

On average, southern Alberta receives minimum daily temperatures colder than -30°C less than 10 times in a year. The number of days below -30°C increases as one goes farther north. Lethbridge CDA receives an average of 5.2 days colder than -30°C, including about four days during December and January. In contrast, Cold Lake Airport (about 130 km north of Lloydminster) receives a total of 15.4 days with temperatures colder than -30°C.

The distribution shown on this map is very similar to the distribution of January daily mean temperatures (Map 4). Since January is one of the coldest months of the year in Alberta, the similar pattern is an indication of the strong link between January daily mean temperatures and the number of cold days.

Map 28 – Annual number of days with precipitation > 0.2 mm, 1971 to 2000

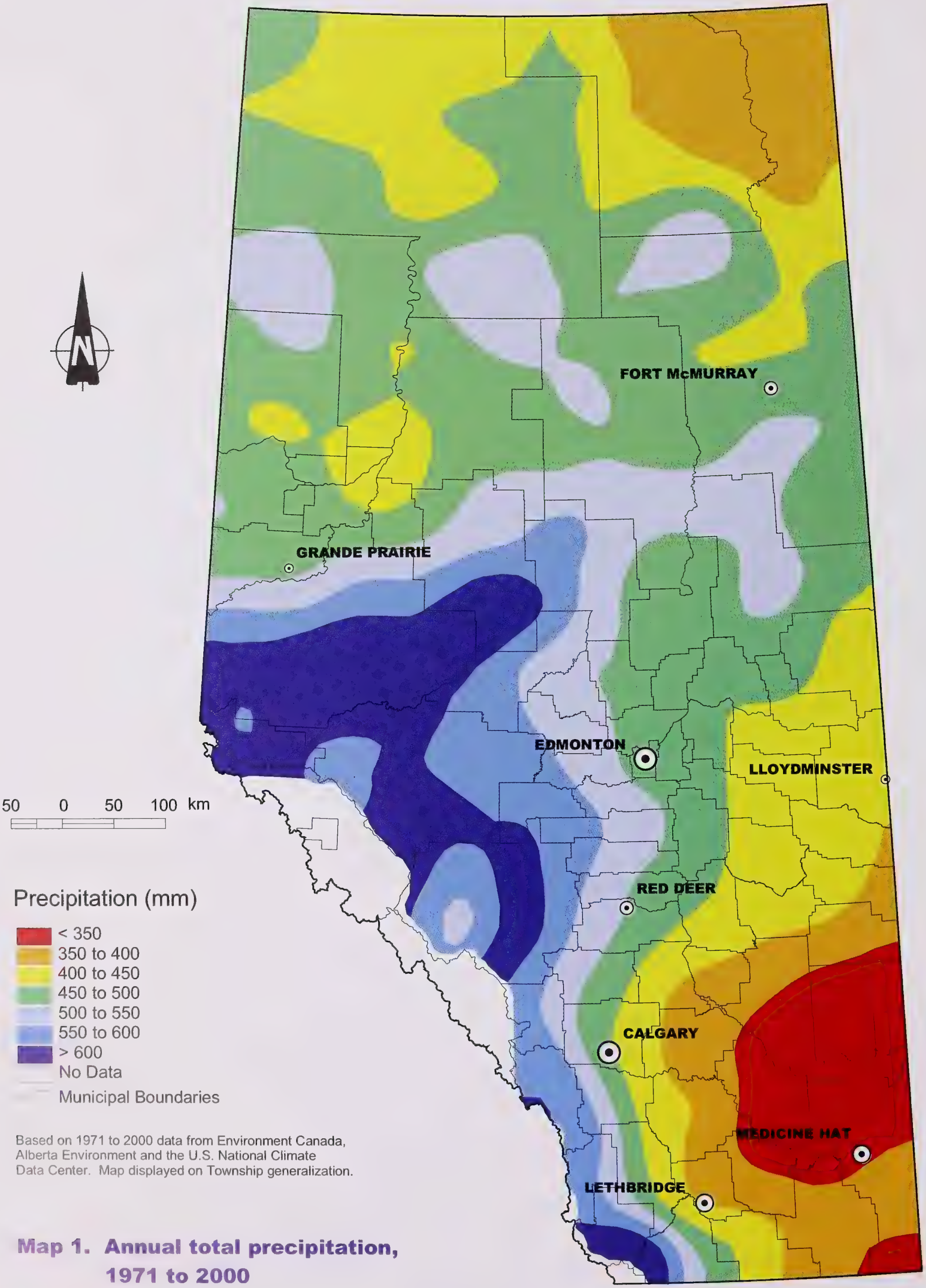
On average, the Special Areas in southeast Alberta (see Figure 1) receive less than 75 days with precipitation greater than 0.2 mm in a year. The frequency of precipitation increases the farther north and west one goes from the Special Areas. Fort McMurray receives over 142 days with precipitation on average in a year, while the Oyen Cappon station in the Special Areas receives 51 days.

Map 29 – Annual number of days with precipitation > 25 mm, 1971 to 2000

Most of Alberta receives daily precipitation totals greater than 25 mm, one to three times a year, on average. Southeast Alberta receives totals greater than 25 mm less than one day per year.

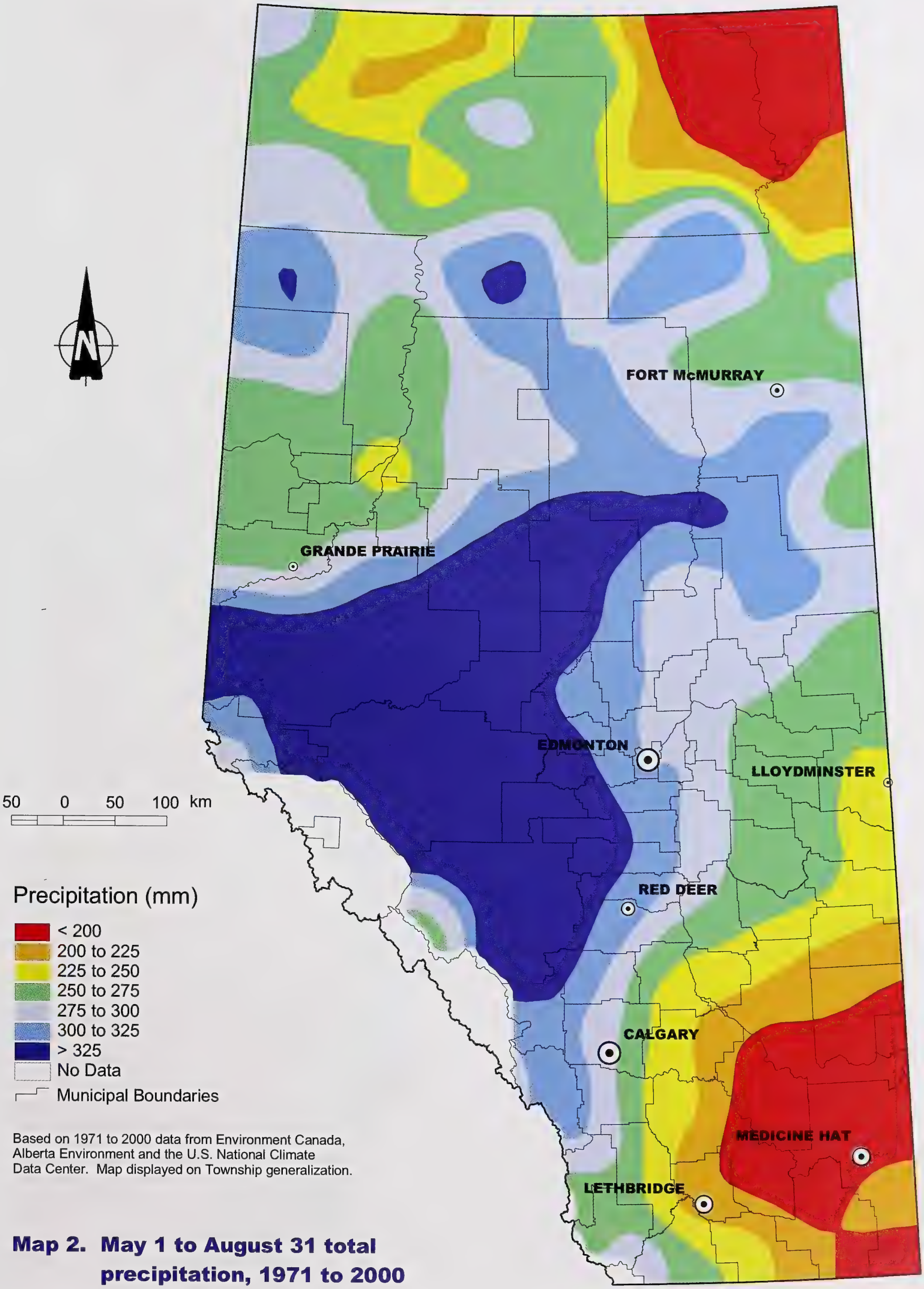
maps

MAPS



Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 1. Annual total precipitation, 1971 to 2000



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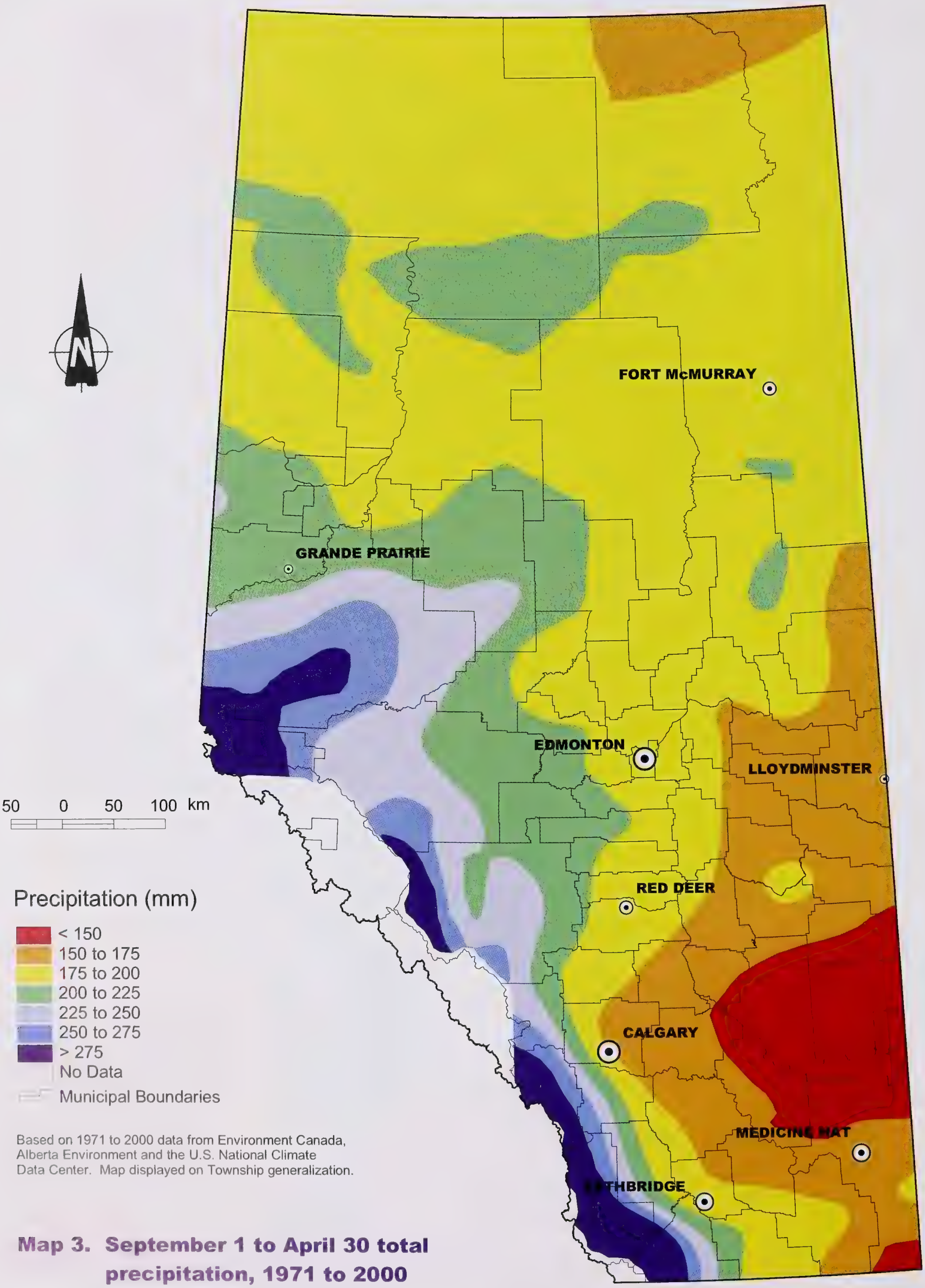
Map 2. May 1 to August 31 total precipitation, 1971 to 2000



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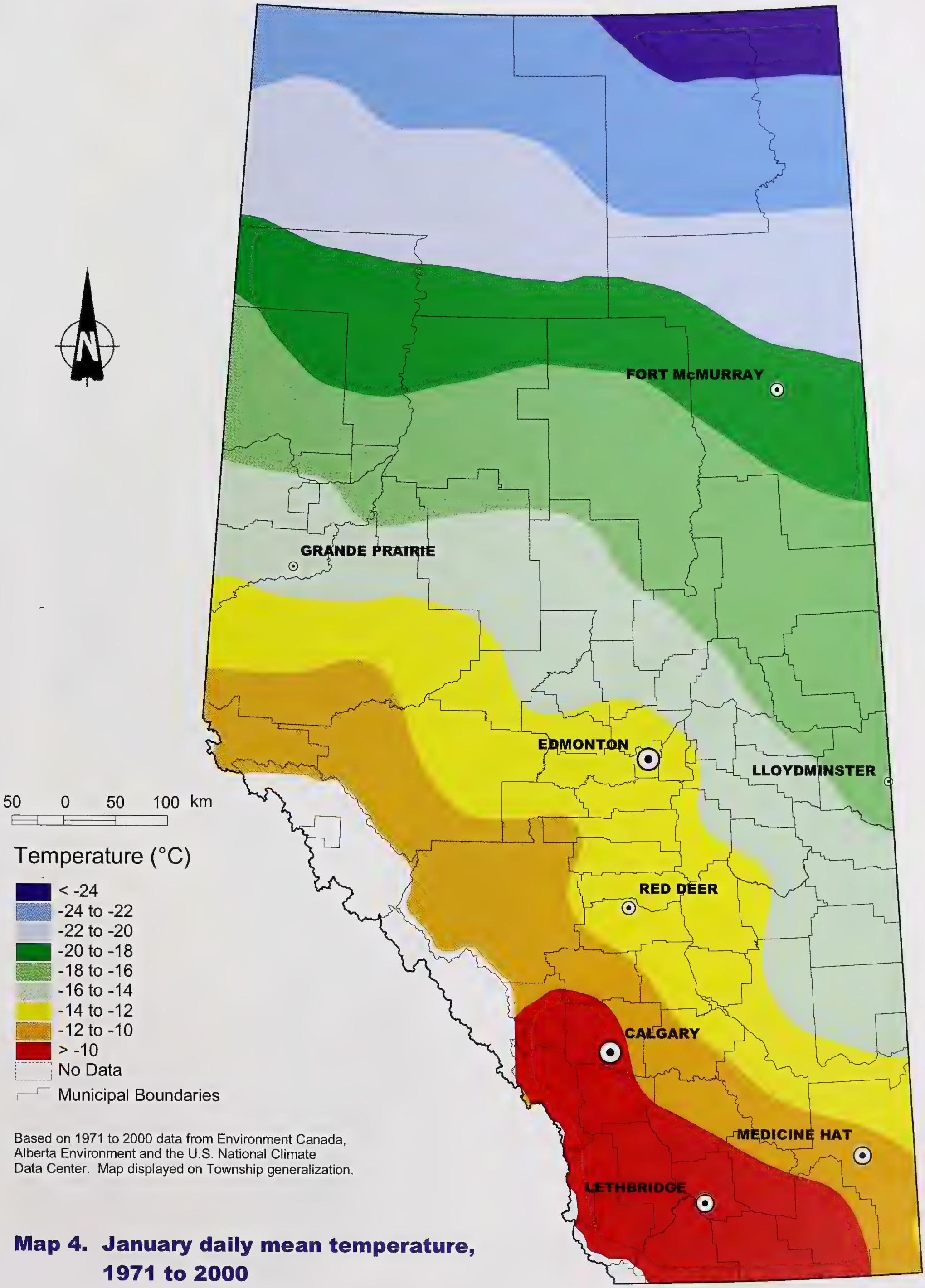
Map 3. September 1 to April 30 total precipitation, 1971 to 2000



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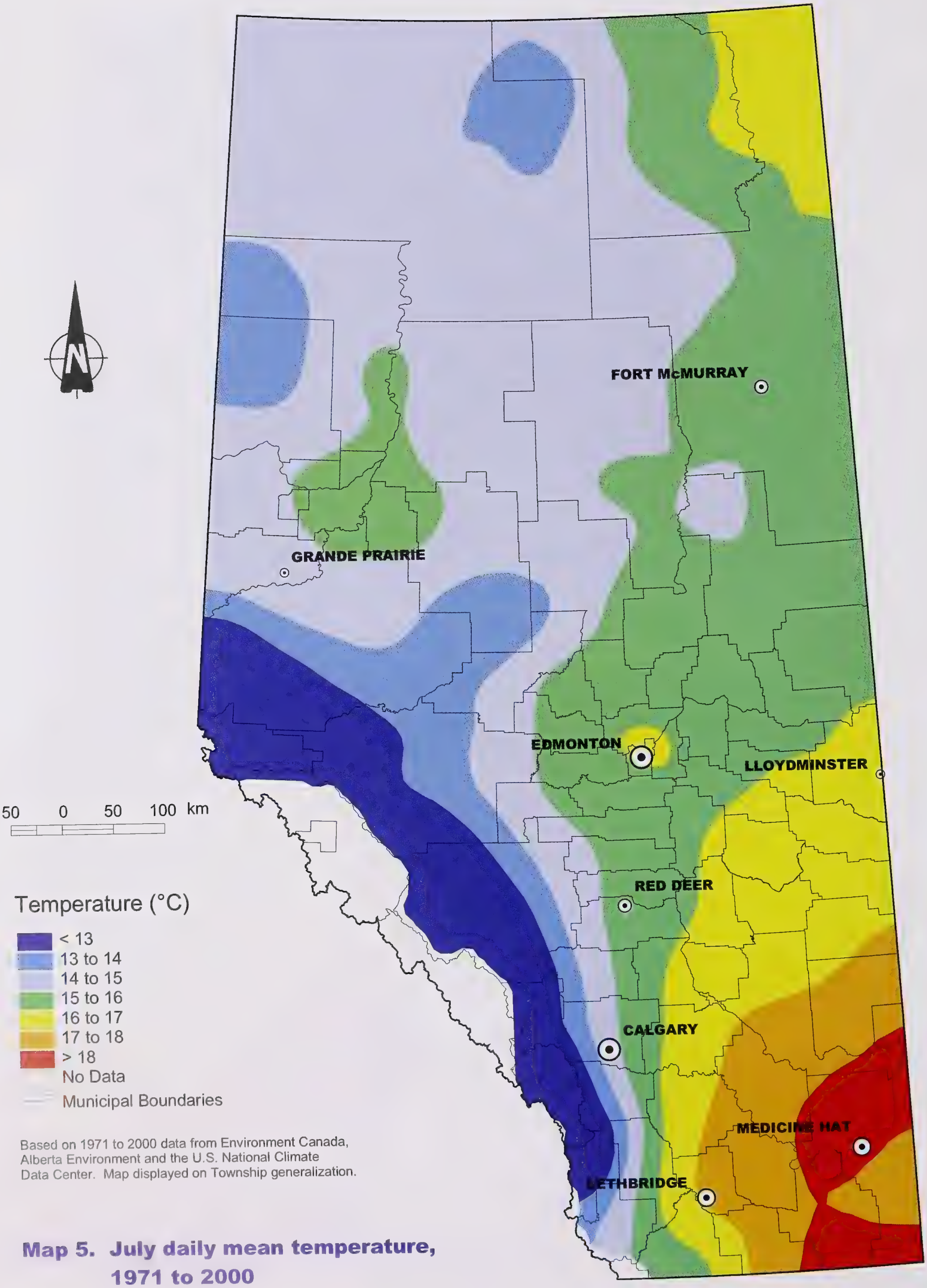
Map 4. January daily mean temperature, 1971 to 2000



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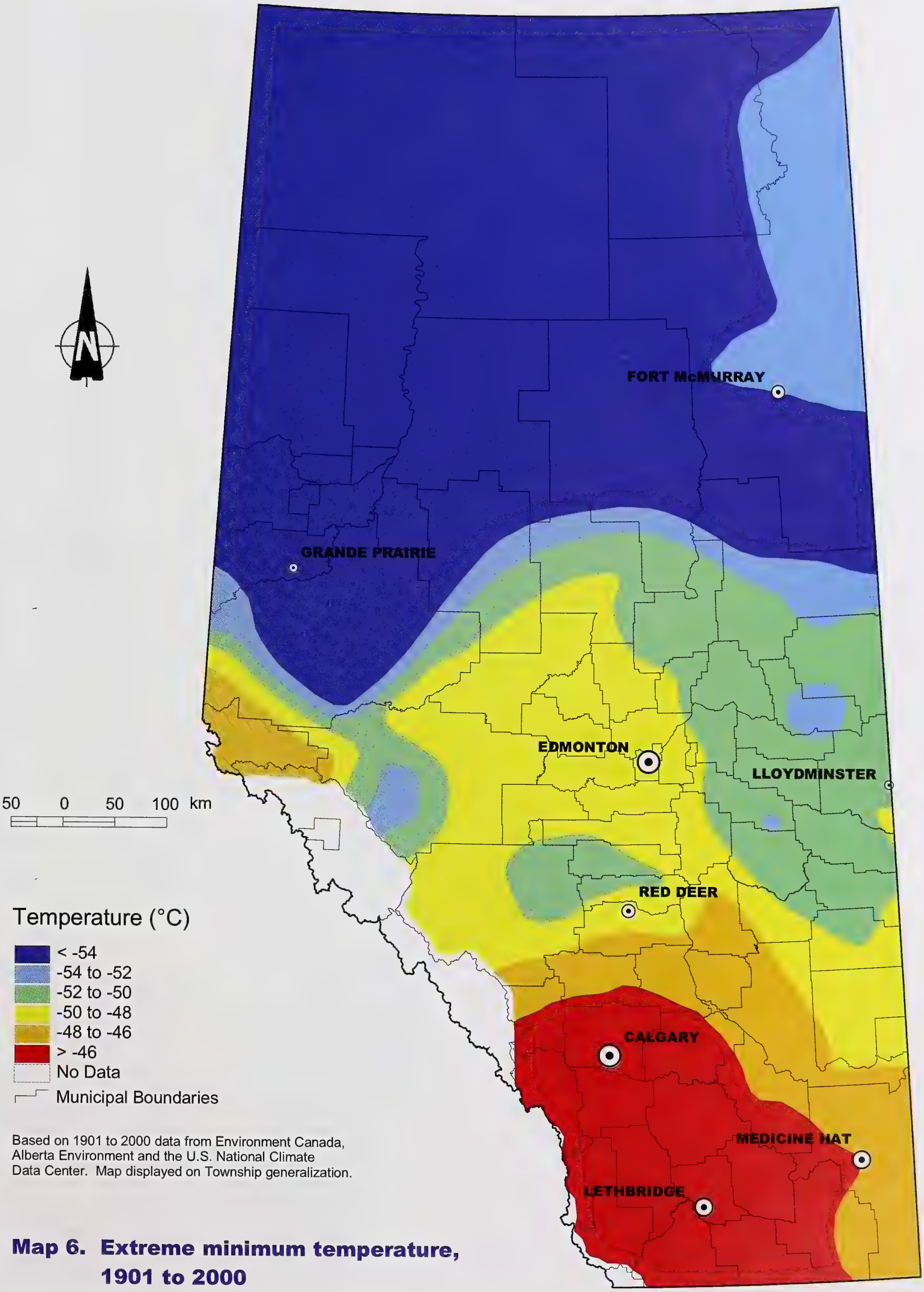
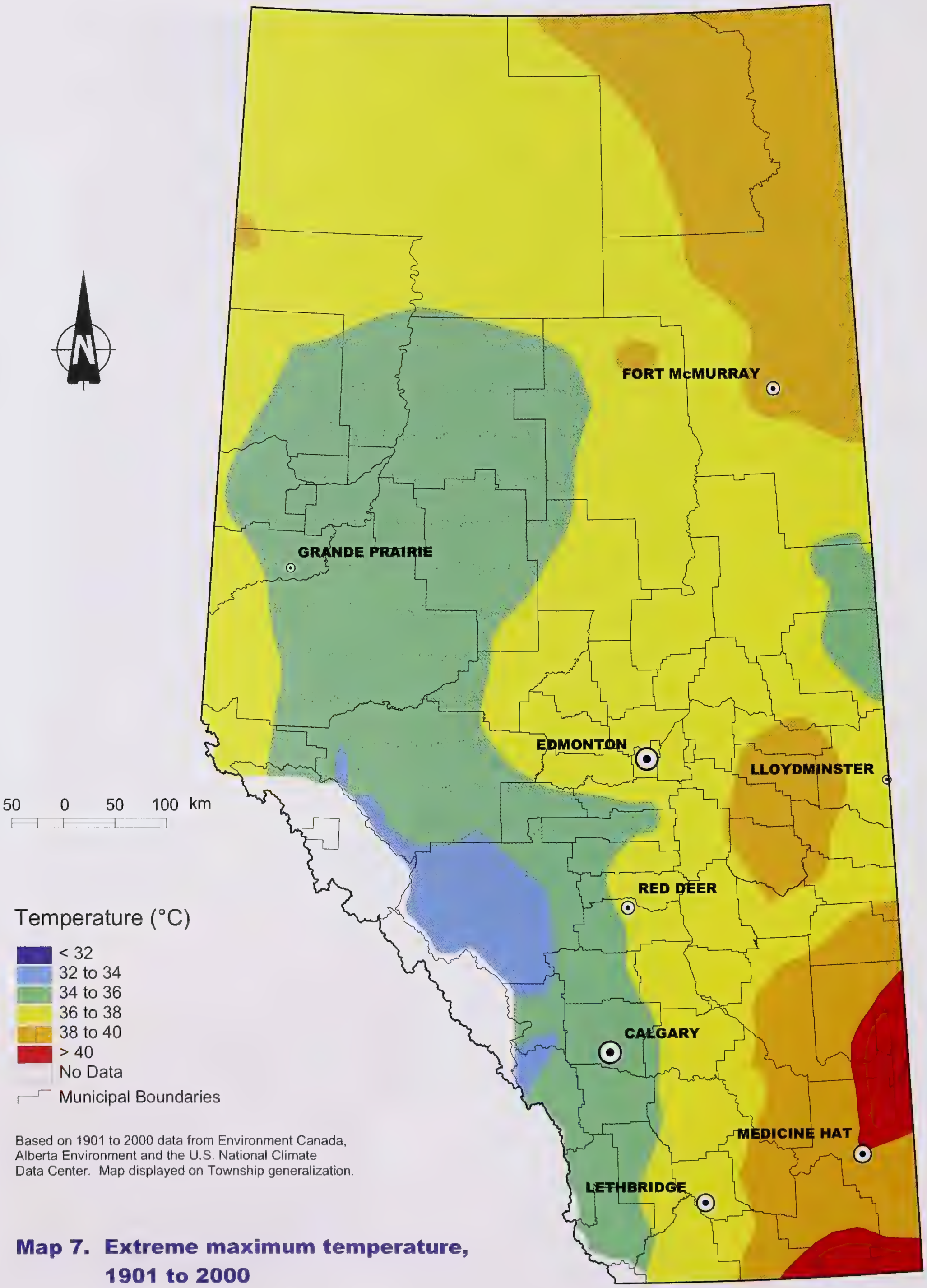
Map 5. July daily mean temperature, 1971 to 2000



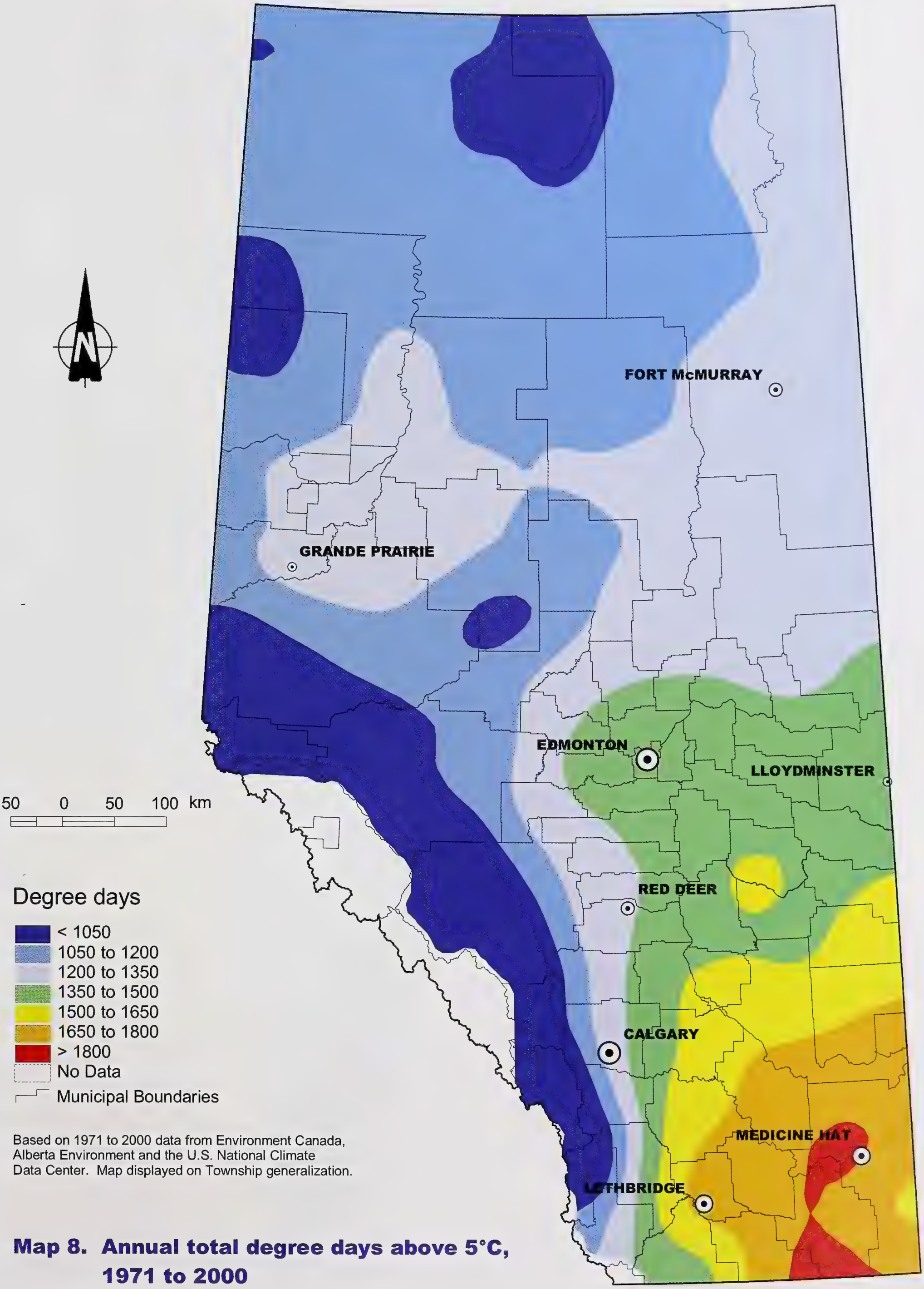
Based on 1901 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 6. Extreme minimum temperature, 1901 to 2000



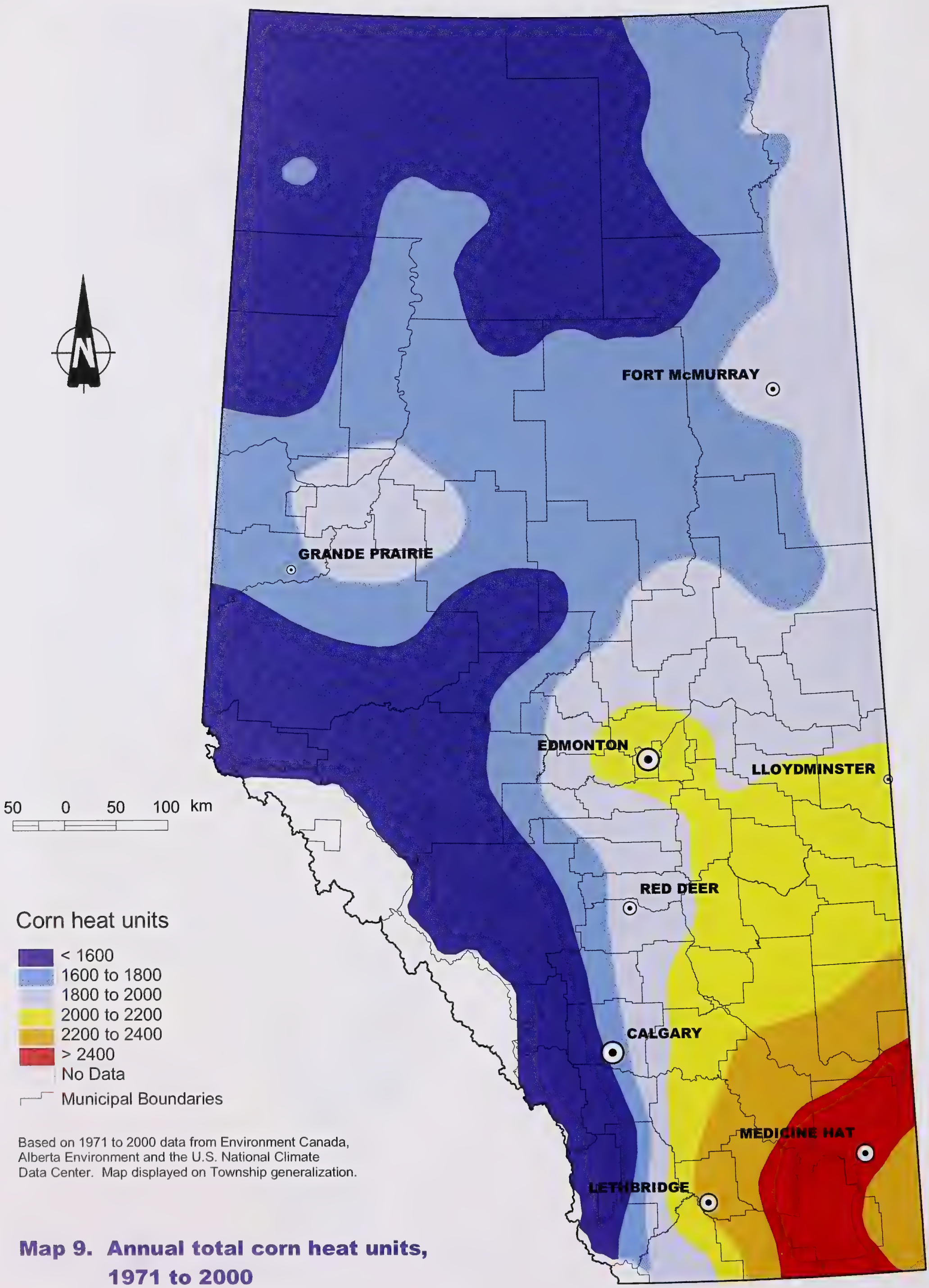
Based on 1901 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 7. Extreme maximum temperature, 1901 to 2000



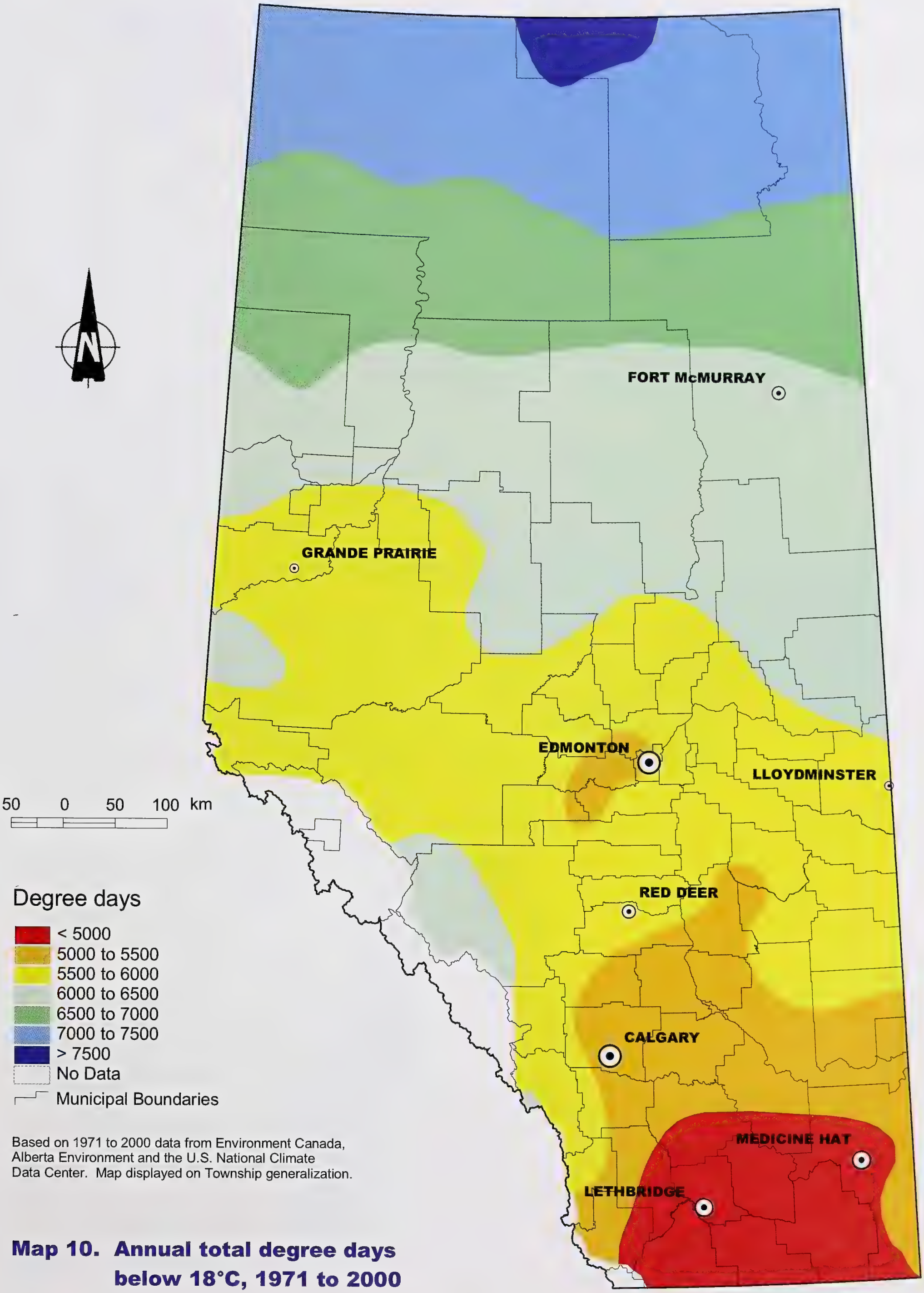
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 8. Annual total degree days above 5°C, 1971 to 2000



Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 9. Annual total corn heat units, 1971 to 2000



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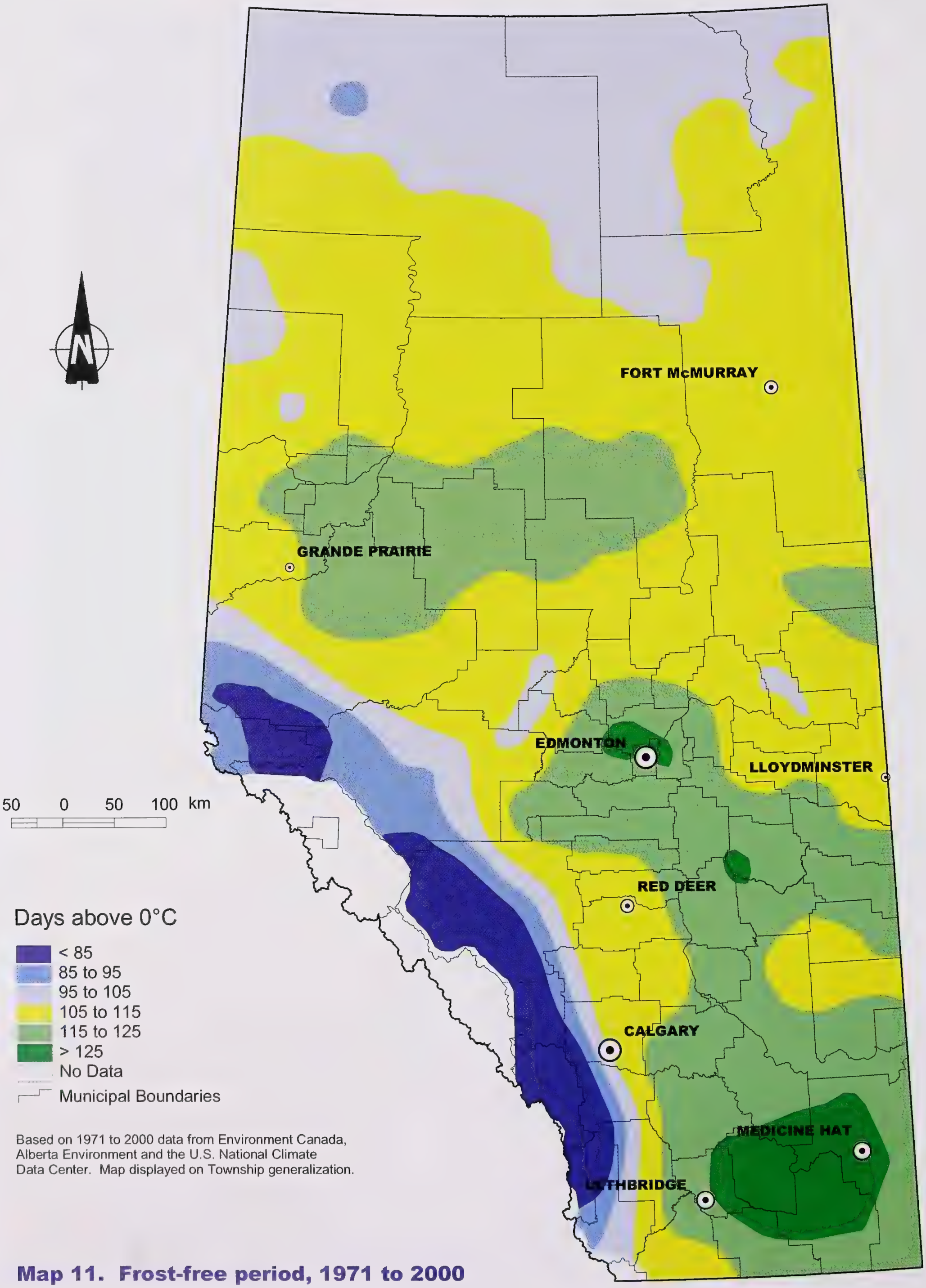
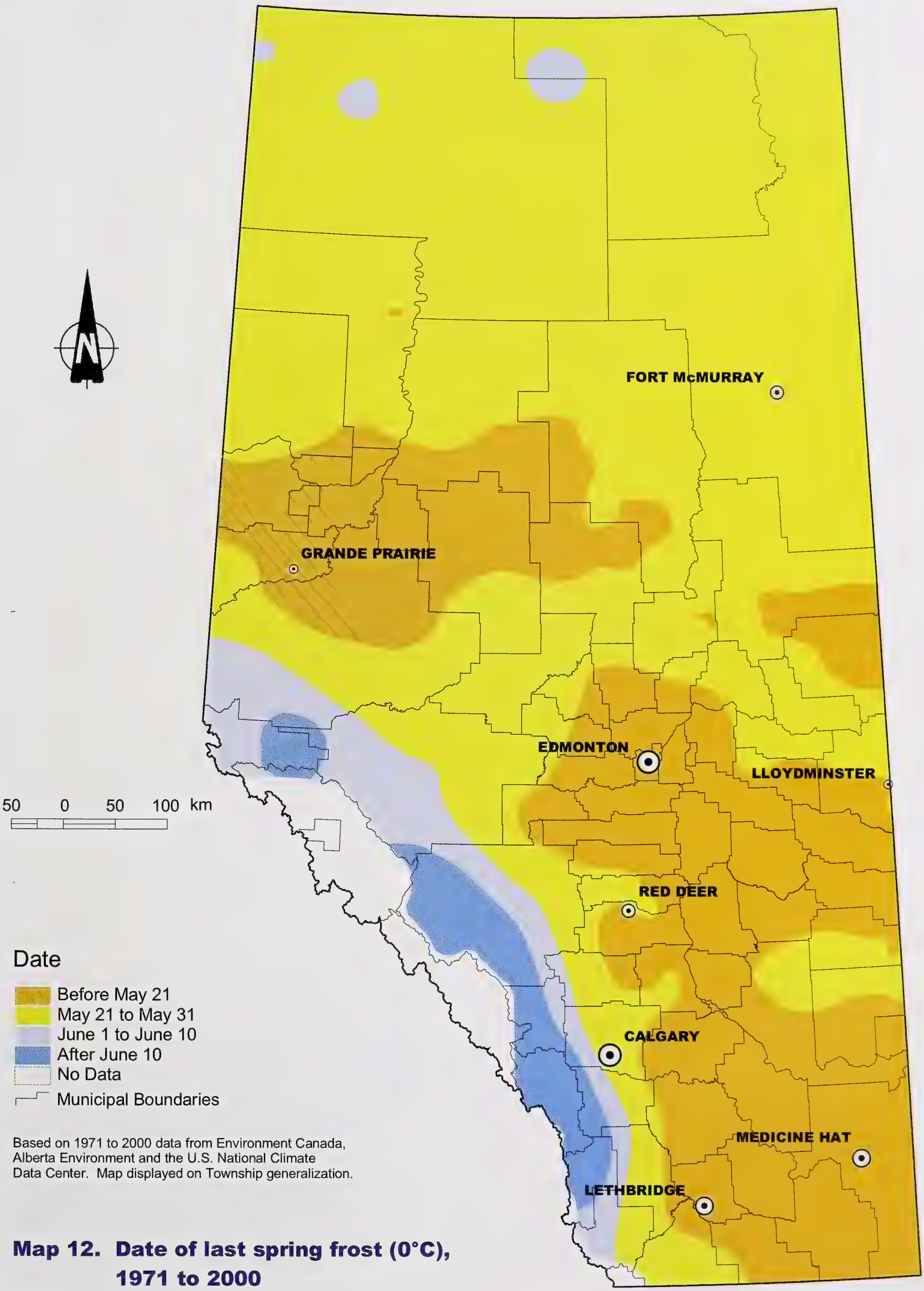
Map 10. Annual total degree days below 18°C, 1971 to 2000



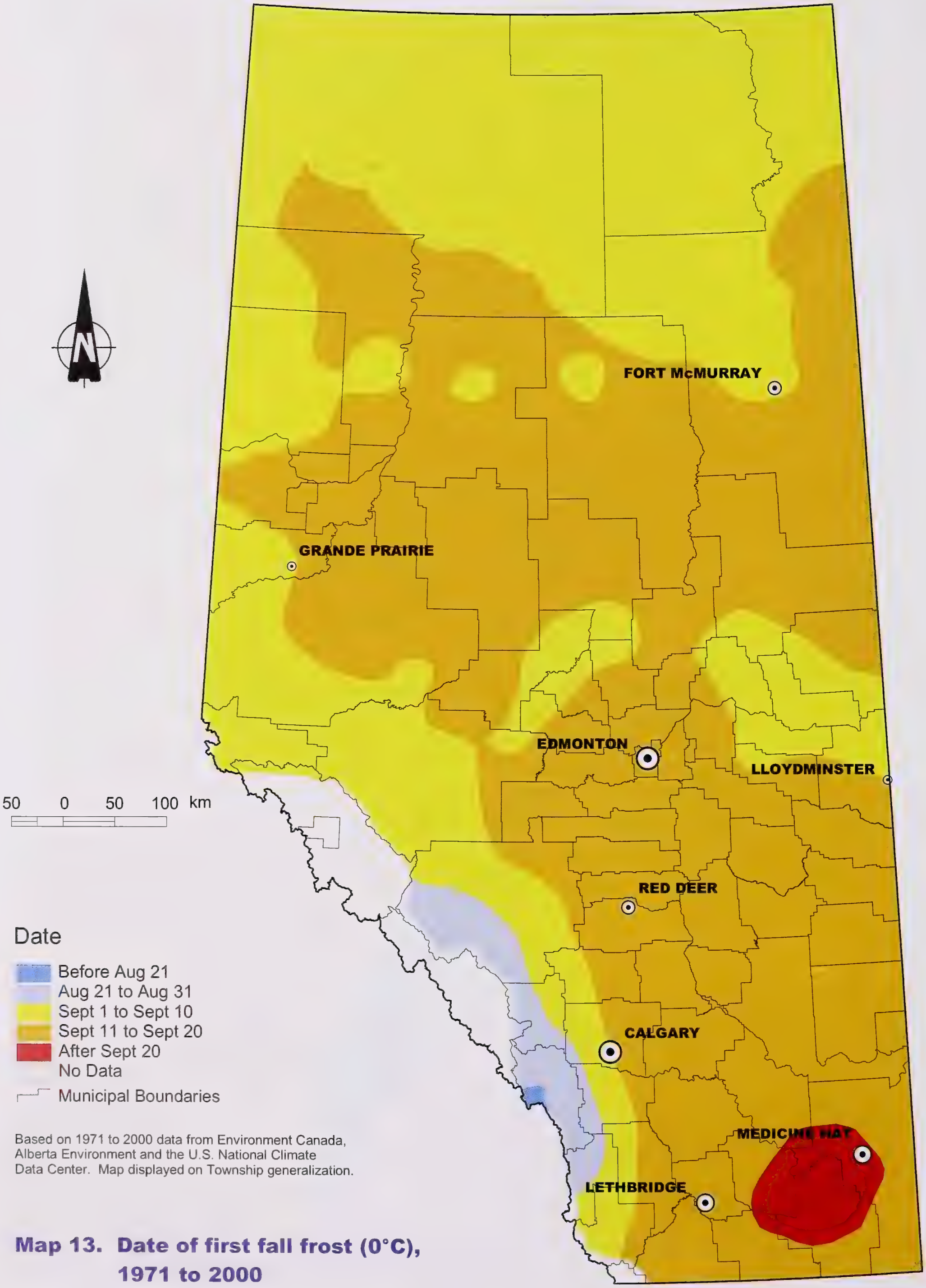
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 11. Frost-free period, 1971 to 2000



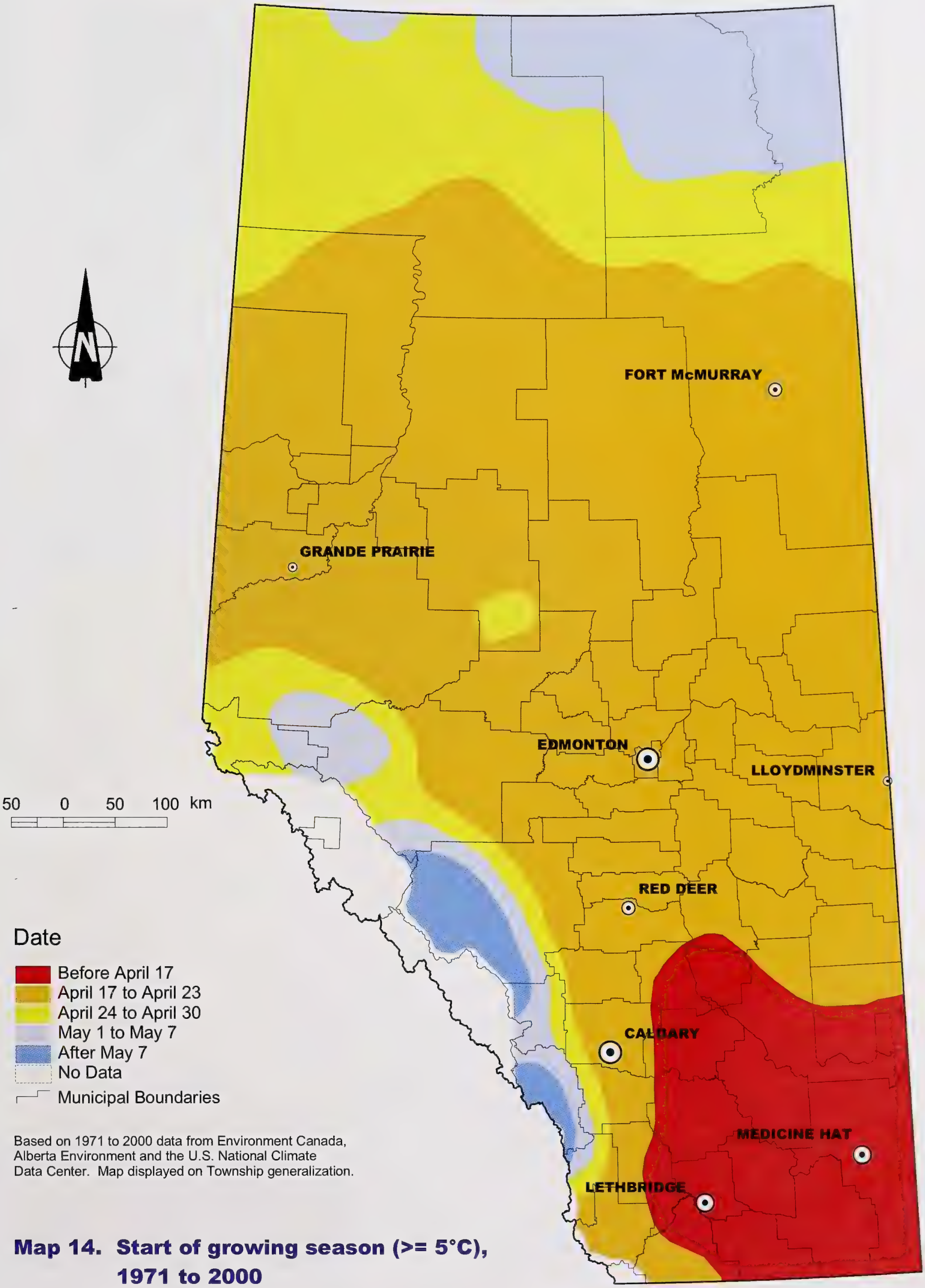
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 12. Date of last spring frost (0°C), 1971 to 2000



Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 13. Date of first fall frost (0°C), 1971 to 2000



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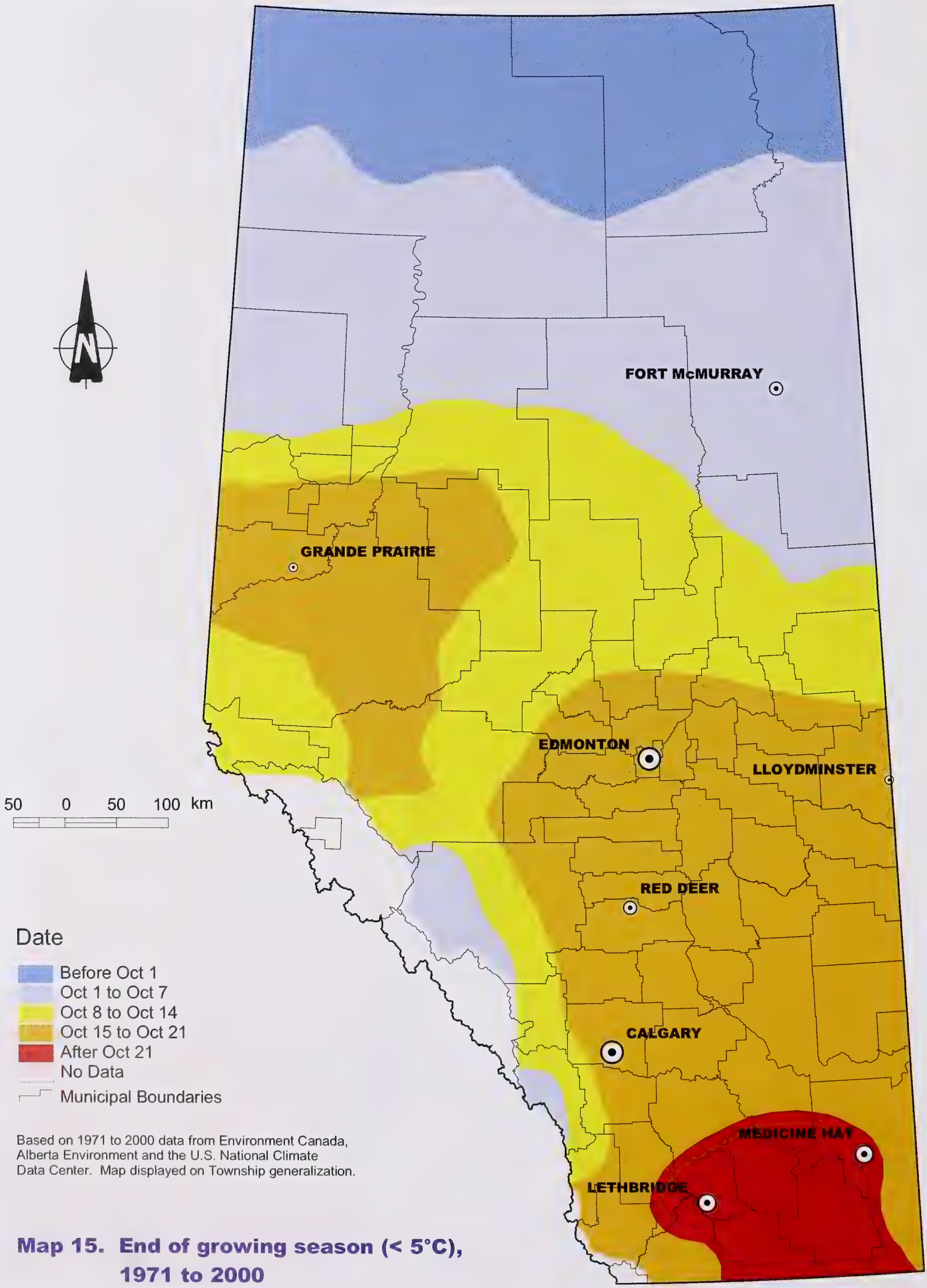
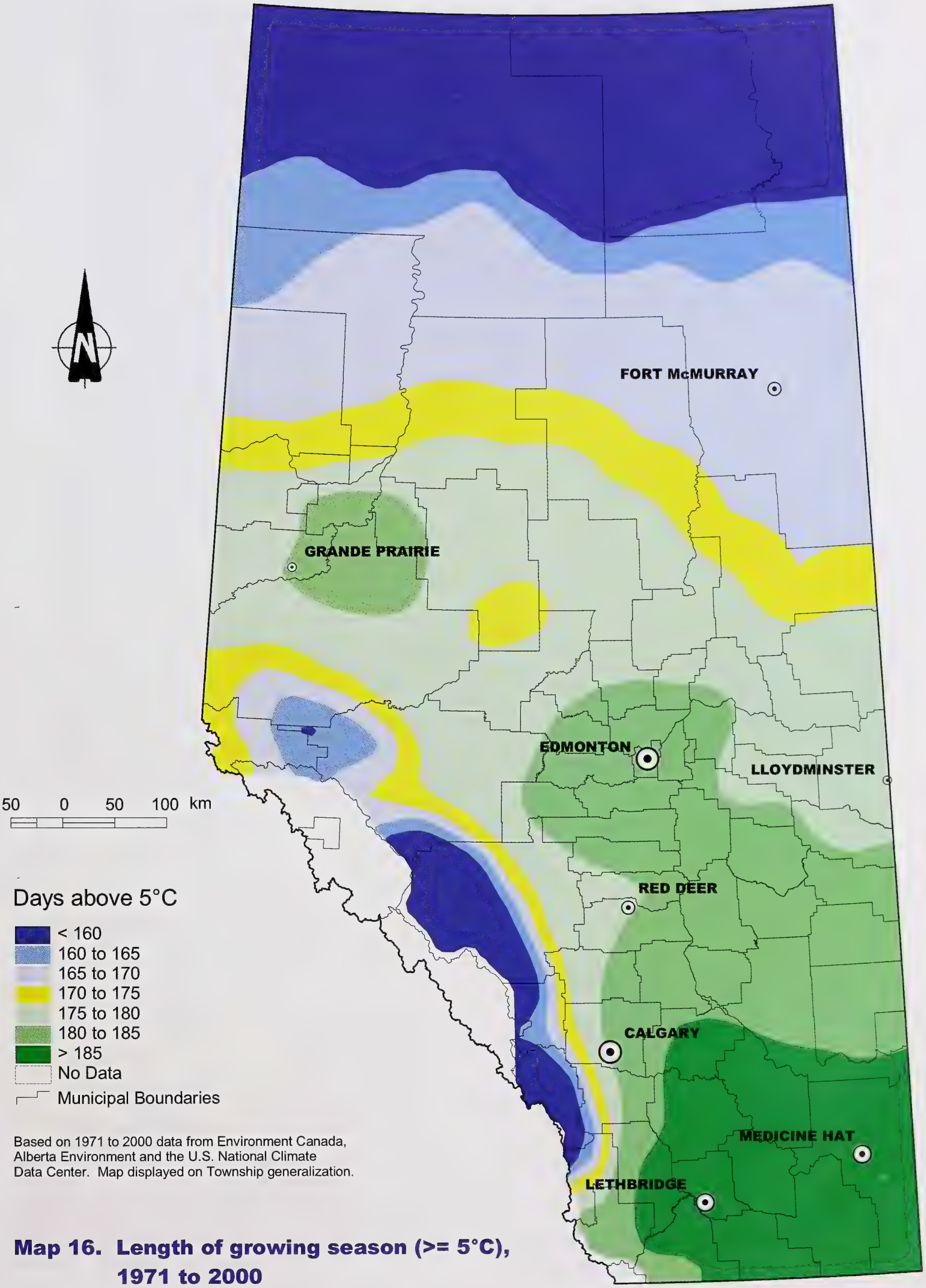
Map 14. Start of growing season (>= 5°C), 1971 to 2000



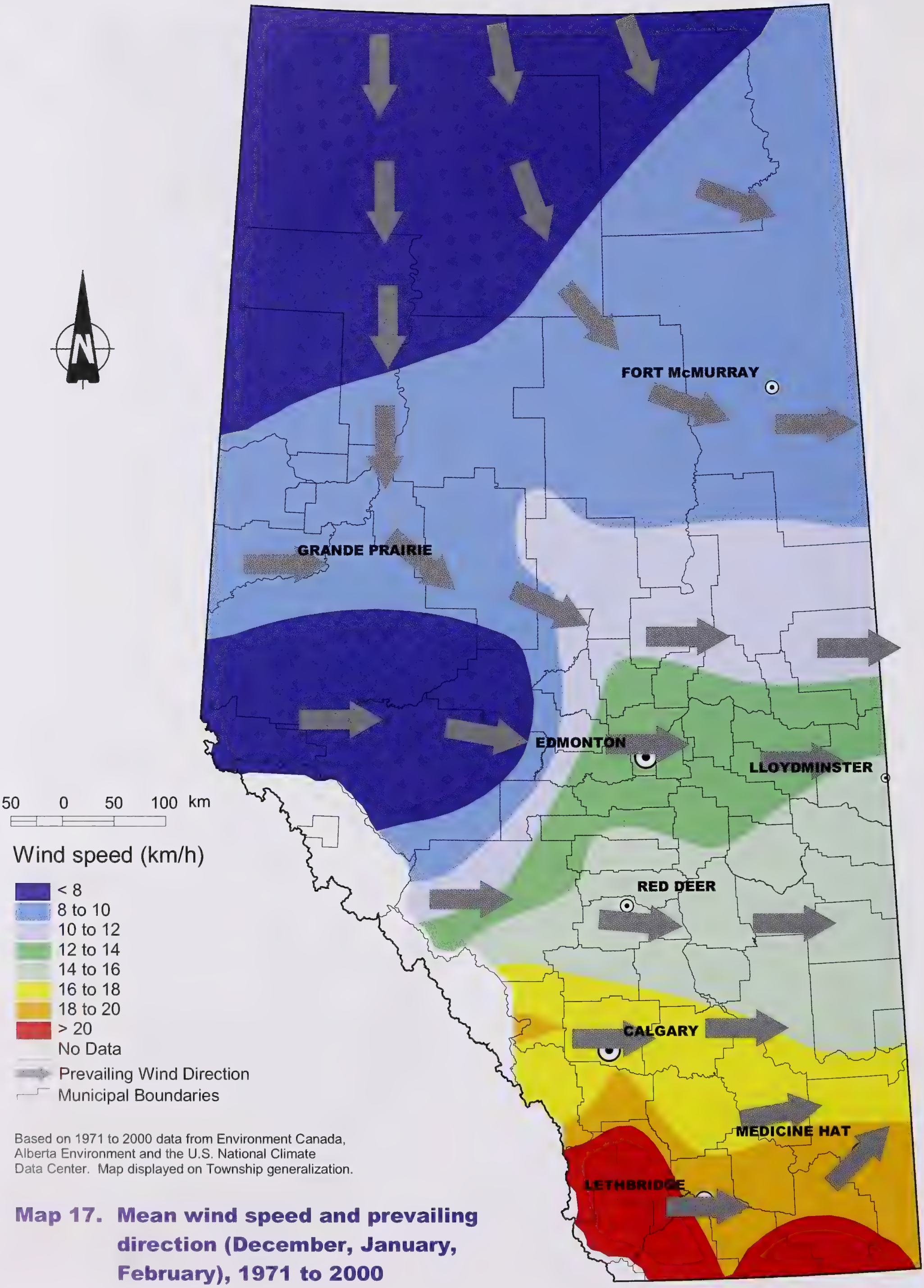
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 15. End of growing season (< 5°C), 1971 to 2000



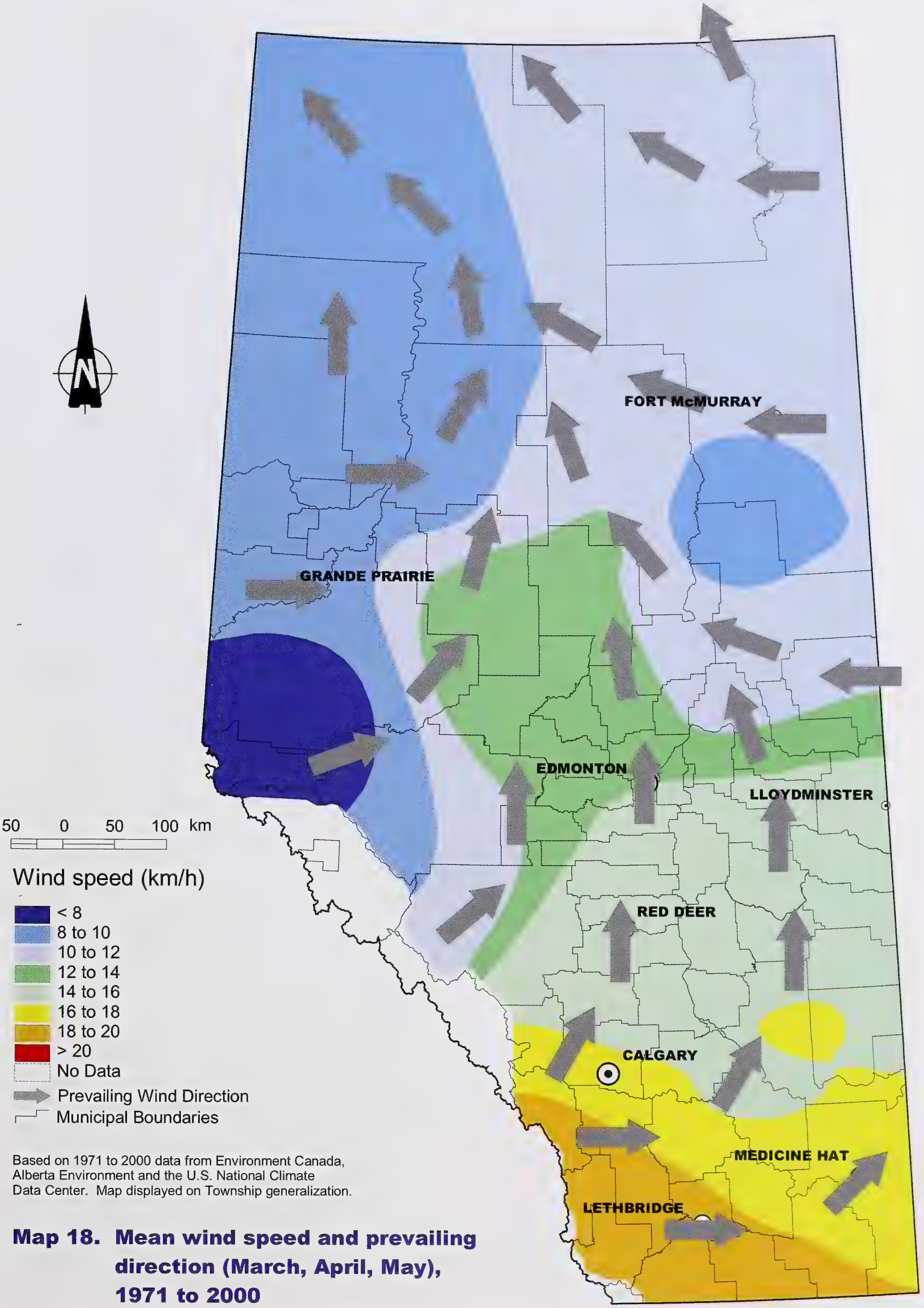
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 16. Length of growing season (>= 5°C), 1971 to 2000



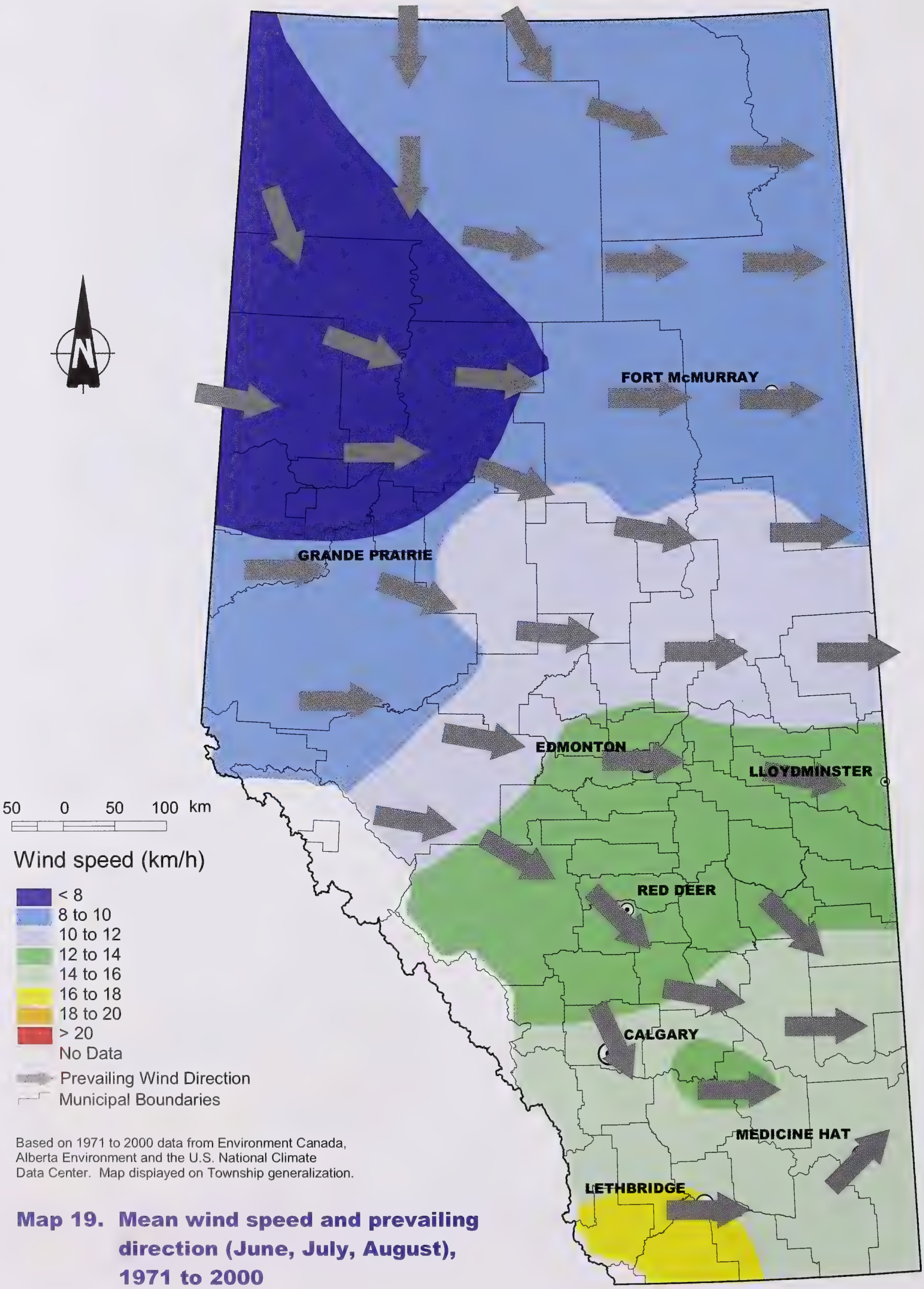
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 17. Mean wind speed and prevailing direction (December, January, February), 1971 to 2000



Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 18. Mean wind speed and prevailing direction (March, April, May), 1971 to 2000



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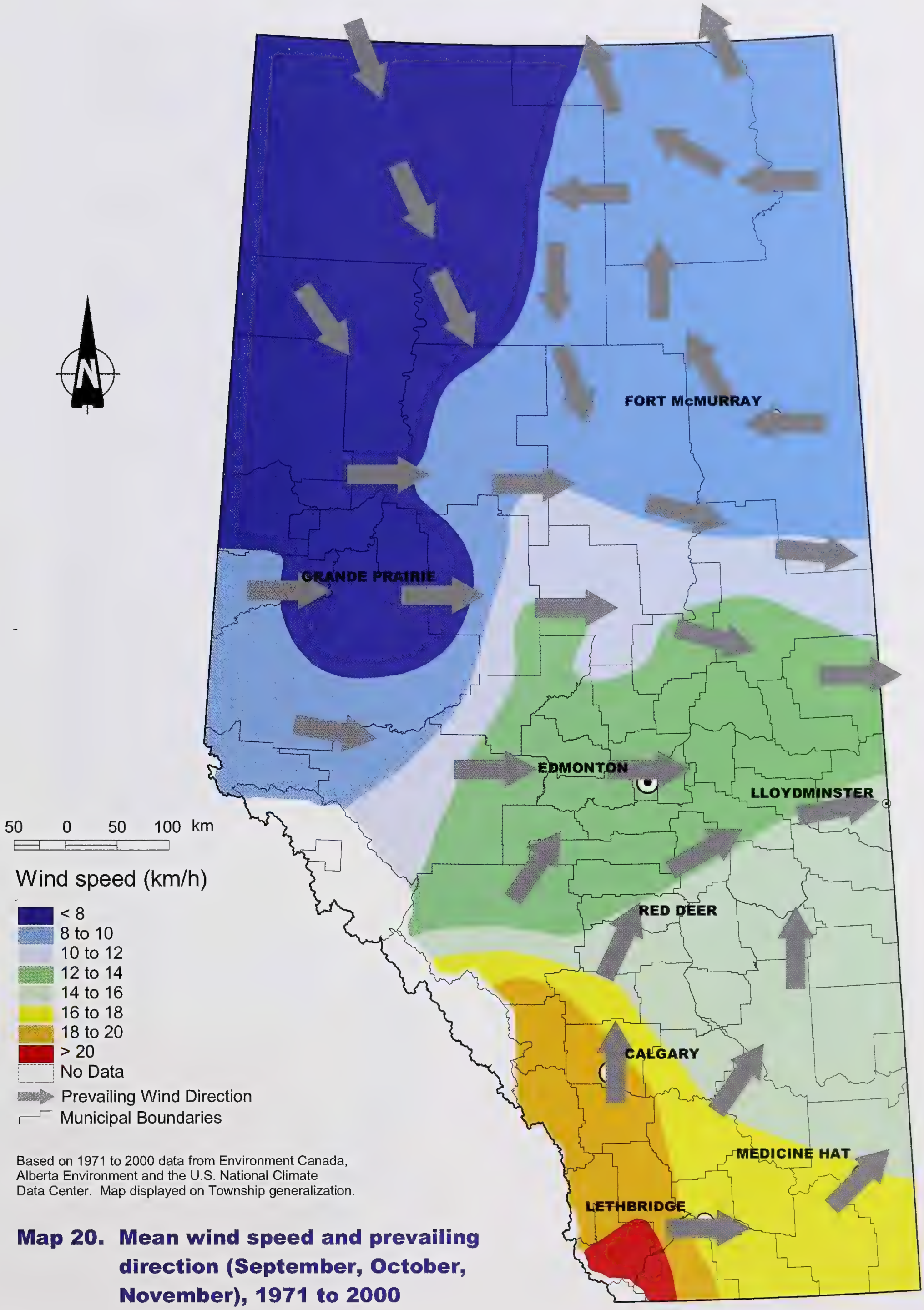
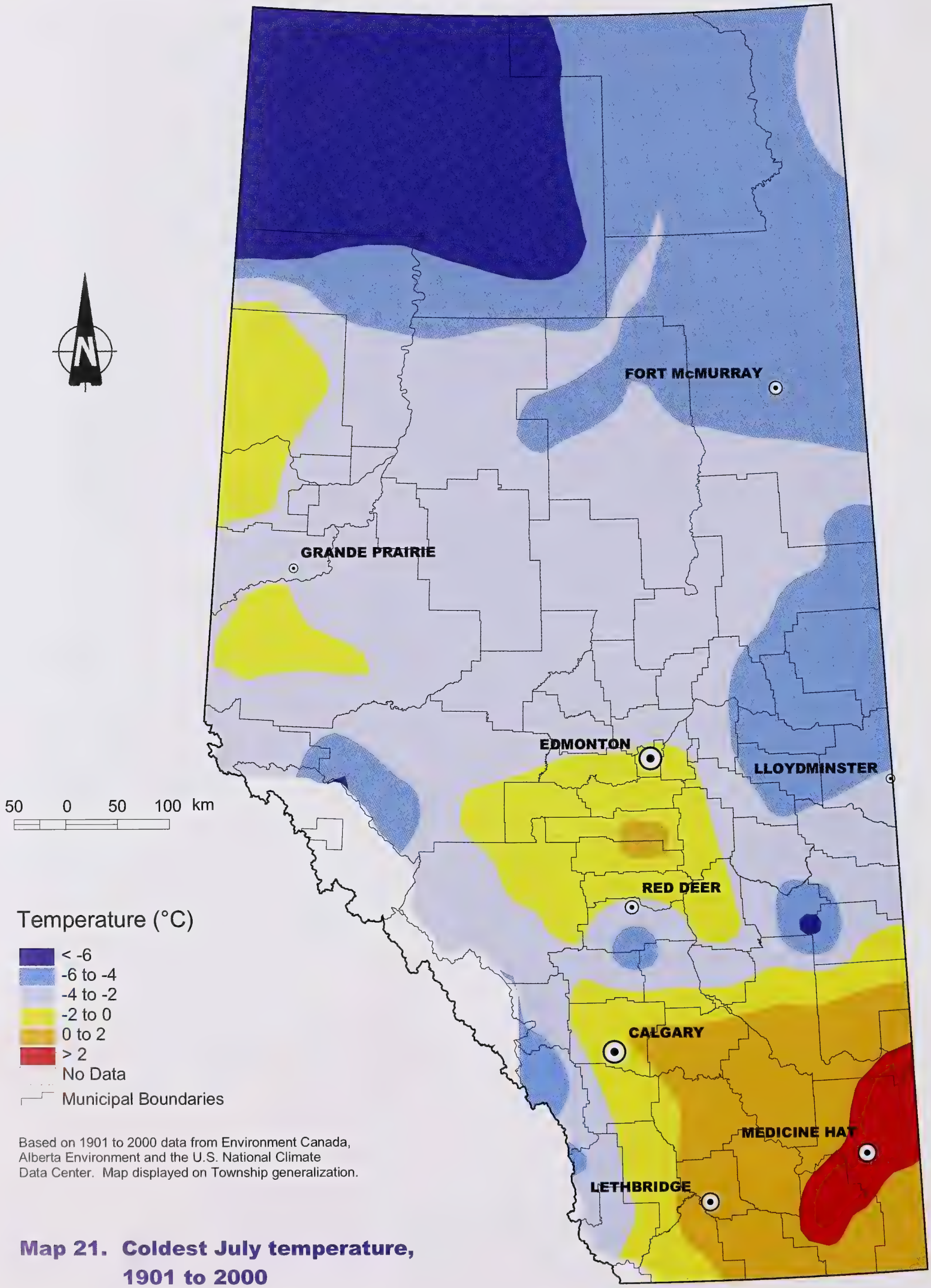
Map 19. Mean wind speed and prevailing direction (June, July, August), 1971 to 2000



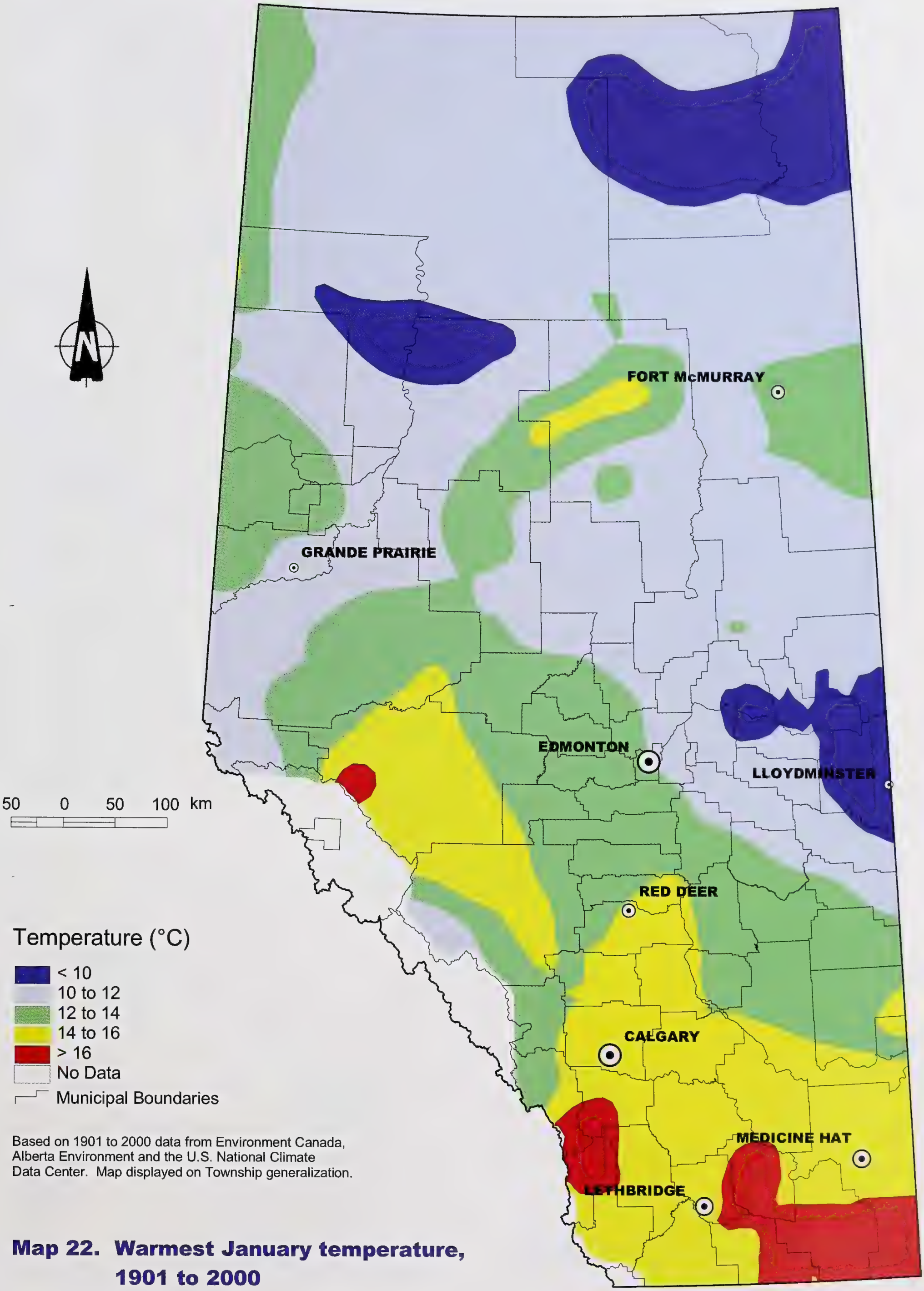
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 20. Mean wind speed and prevailing direction (September, October, November), 1971 to 2000



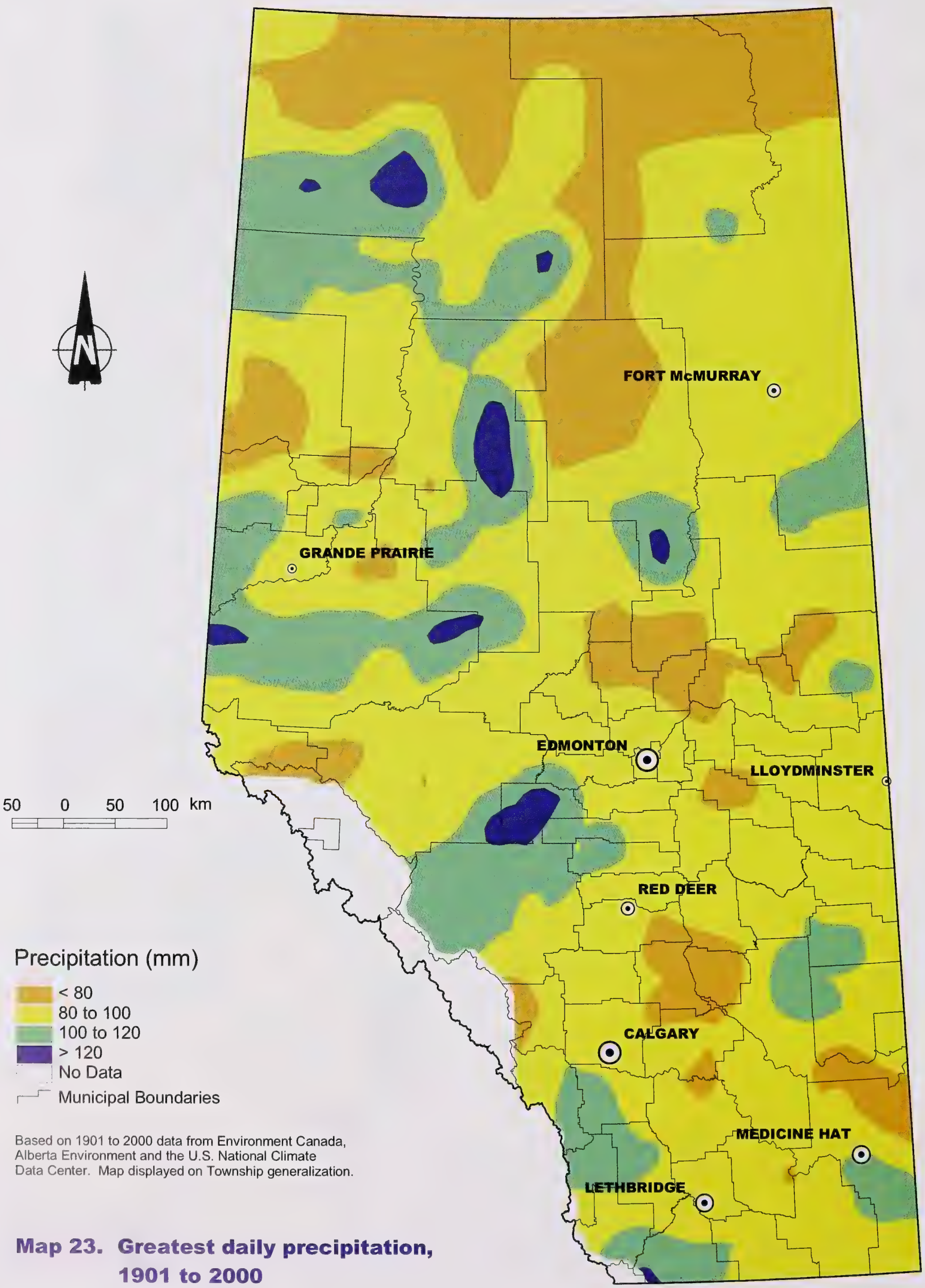
Based on 1901 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 21. Coldest July temperature, 1901 to 2000



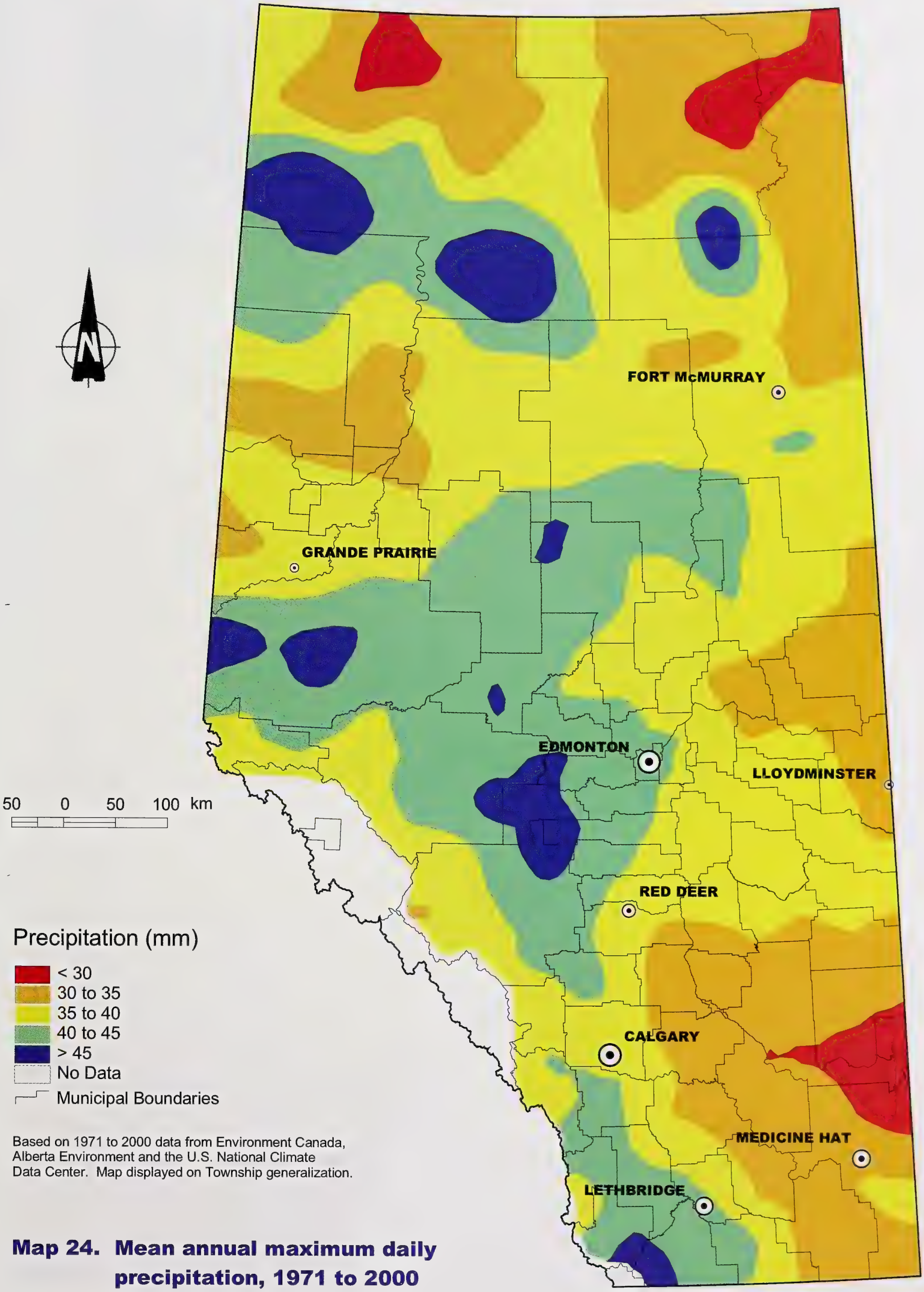
Based on 1901 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 22. Warmest January temperature, 1901 to 2000



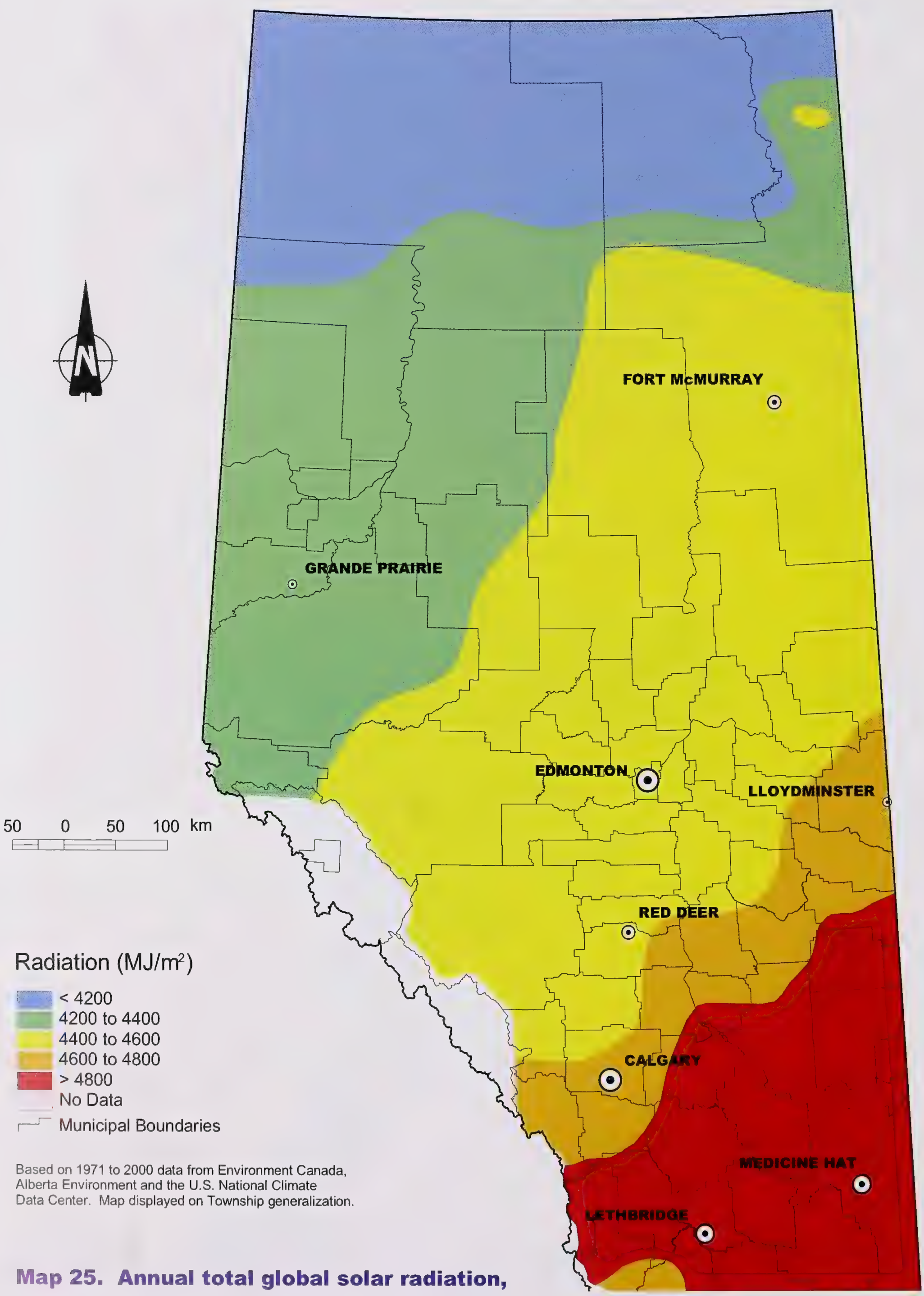
Based on 1901 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 23. Greatest daily precipitation, 1901 to 2000



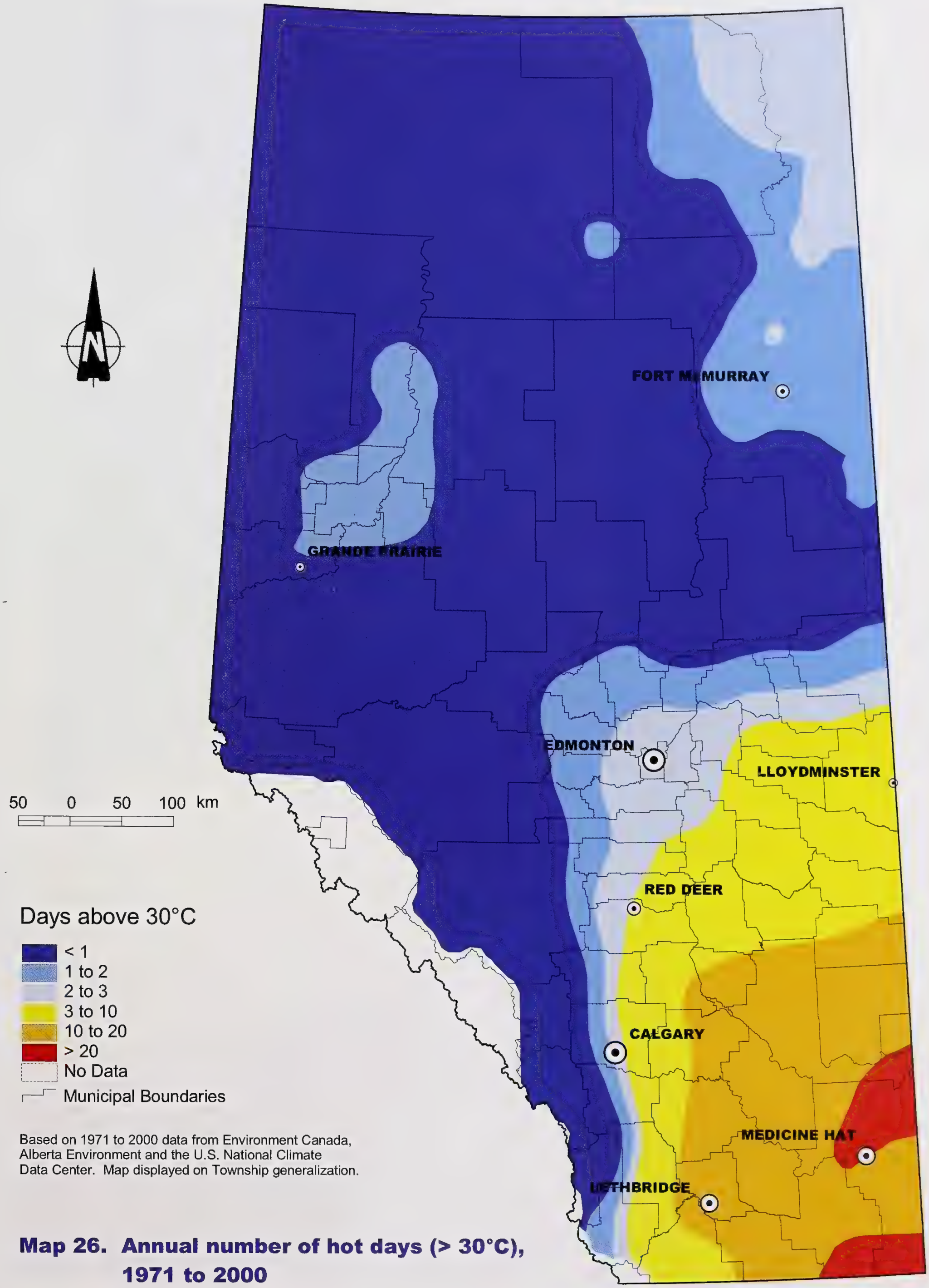
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 24. Mean annual maximum daily precipitation, 1971 to 2000



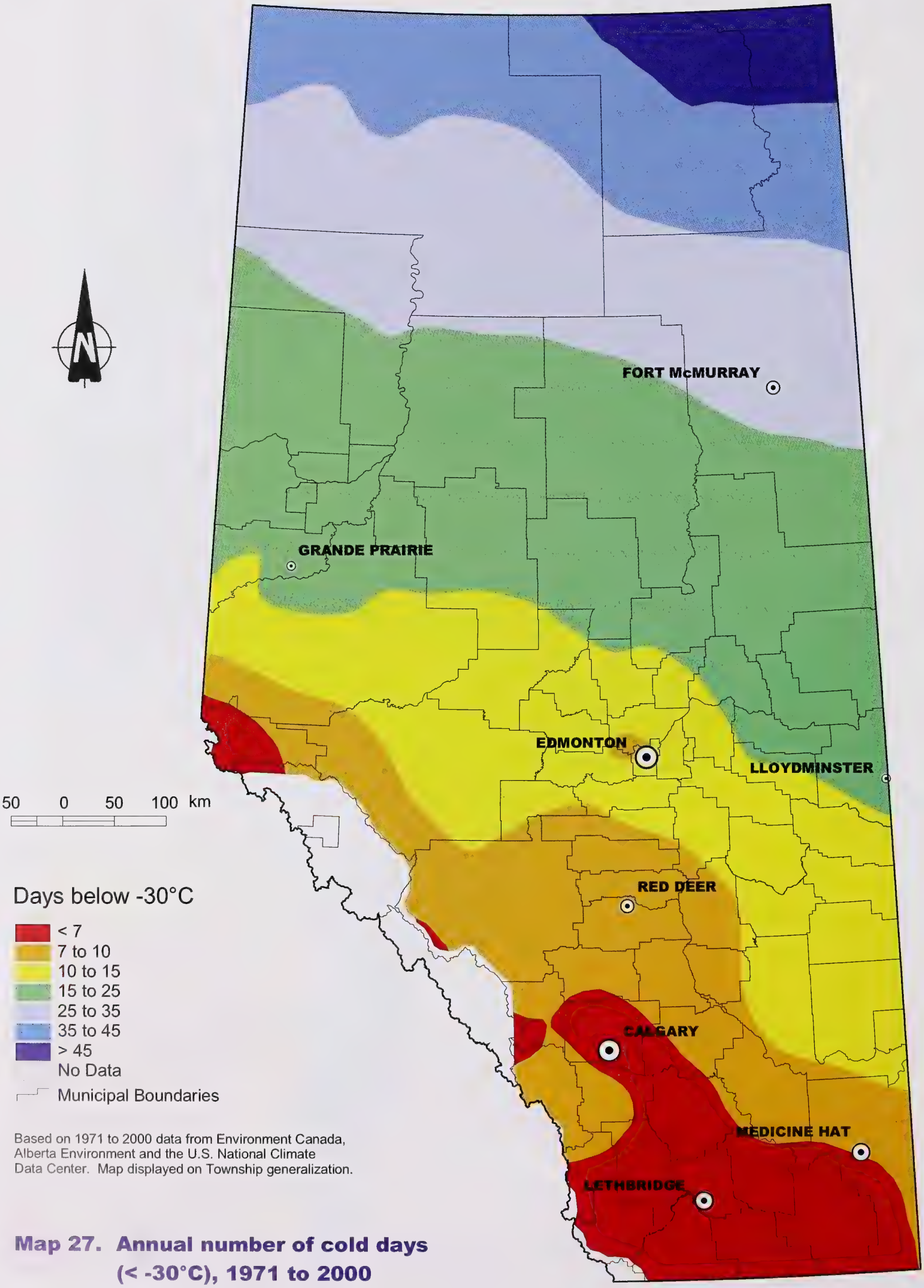
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 25. Annual total global solar radiation,



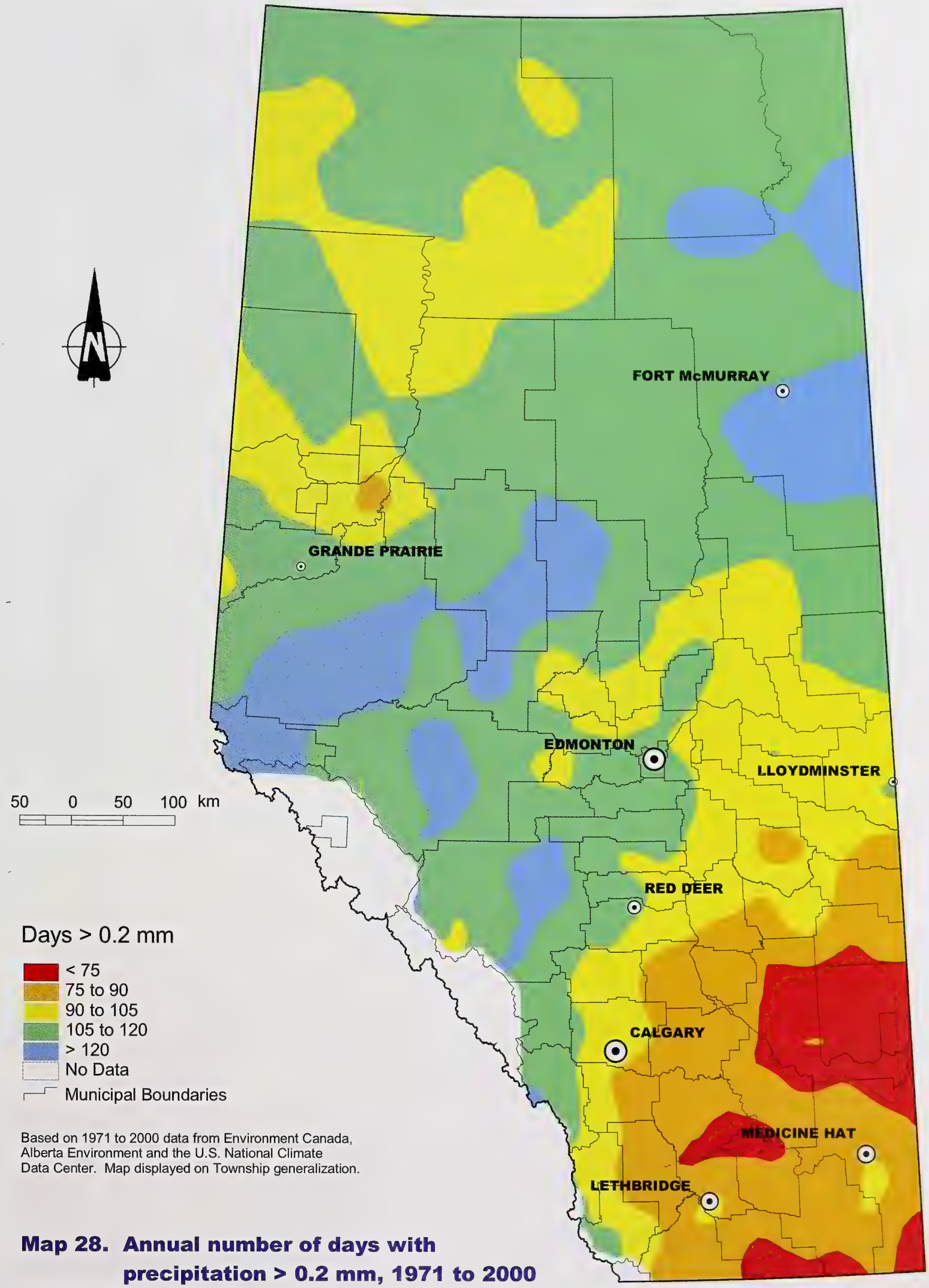
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 26. Annual number of hot days (> 30°C), 1971 to 2000



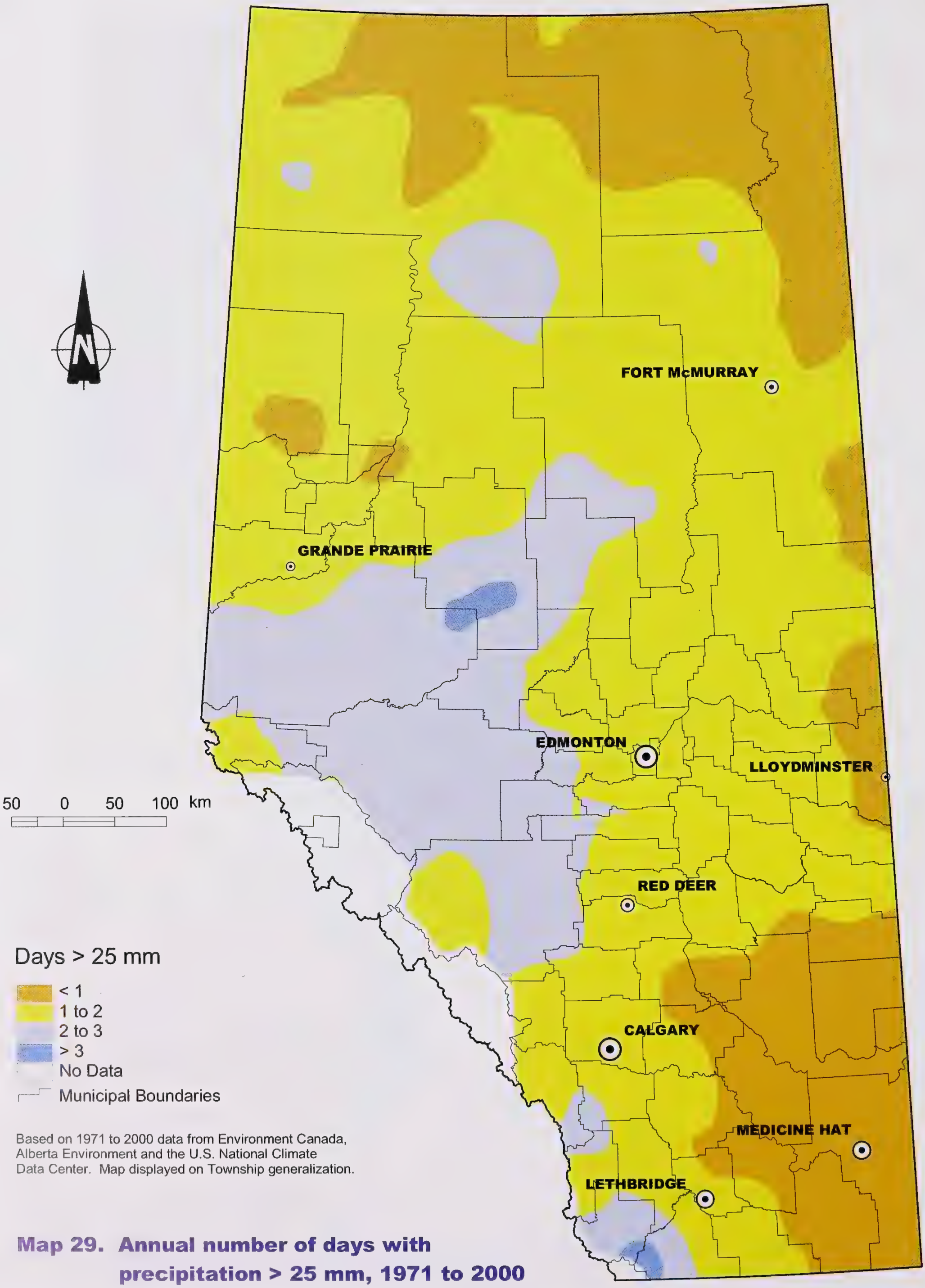
Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 27. Annual number of cold days (< -30°C), 1971 to 2000



Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 28. Annual number of days with precipitation > 0.2 mm, 1971 to 2000



Based on 1971 to 2000 data from Environment Canada, Alberta Environment and the U.S. National Climate Data Center. Map displayed on Township generalization.

Map 29. Annual number of days with precipitation > 25 mm, 1971 to 2000

INTERPOLATION OF CLIMATE STATION DATA

The maps in this 1971 to 2000 Atlas are based on data from all the Alberta stations (Figure 5), including data from many new stations that were not available for the previous edition of the Atlas. Along with this advance, the maps in this edition have been created using more sophisticated computerized ***interpolation*** methods that remove the need to adjust the data for such problems as missing data and allow the use of all available quality controlled daily climate data.

Each station collects data specific to the station's particular location. However, the maps in the Atlas show information for the entire area of the province, as if the climate values are known for all possible locations in the province, rather than only at the station locations. Therefore, climate values need to be assigned for the locations between stations. The process of calculating estimated climate values for locations between weather stations is called interpolation.

Description of the daily climate data interpolated over townships

The Alberta Township Survey System is a grid network dividing the province into equal-size, square parcels of land, for purposes of administering legal land title. The grid specifies squares of land at several resolutions. ***Townships*** are approximately 10 km by 10 km in size. (The surveying was done long before Canada started using the Metric system, so the townships are precisely 6 miles by 6 miles in size.) Each township is divided into 36 ***sections***, 1 mile by 1 mile (1.6 km by 1.6 km) in size. These in turn are divided into ***quarter-sections***, and in residential areas these are further divided into ***land parcels*** and ***lots***.

The townships were selected as the standard land unit for the Alberta agroclimate database because they are small enough to provide detail yet not so small that the database becomes cumbersome and redundant, and also because any location in the province is easily identified by township. Daily weather data for each day from January 1, 1901, to December 31, 2000, were interpolated to the centre point of each of the 6900 townships in Alberta. Few of the stations have complete daily records of 100 years, and some have only a few years or only summer records. The interpolation for any given day in the century was based only on those stations that reported weather values for that day. The interpolation procedure is based on that of Shen et al. (2001).

This interpolation procedure used all available, reliable station data, to generate a database of 36,525 days of daily data for each of 6900 townships, with no missing data. This database has value not only for preparing this Atlas, but also for many other research and analysis purposes, such as soil quality modeling, environmental impact modeling, and assessing agroclimatic change.

Seven basic and directly observed weather parameters have been interpolated:

1. Daily maximum temperature (degrees Celsius)
2. Daily minimum temperature (degrees Celsius)
3. Daily total precipitation (millimetres)
4. Relative humidity (per cent)
5. Daily total incoming solar radiation (megajoules per square metre)
6. Daily average wind speed (kilometres per hour)
7. Daily wind direction (degrees clockwise from true north and 90° indicating a wind from east)

Other climate parameters described in this Atlas, such as the corn heat units, have been derived from the seven basic parameters.

Construction of the interpolated data set

Original station data

The climate stations within Alberta and just beyond Alberta's borders (4° of longitude to the east and west, 4° of latitude to the north and 2° of latitude to the south) were used for interpolation. Every piece of raw data, except apparently incorrect data, was used in the interpolation.

The temperature and precipitation data cover the entire 100-year period from 1901. Collection of relative humidity data started in 1948, and collection of solar radiation data started in 1957. Determining the prevailing wind direction requires hourly data; collection of hourly data of wind speed and wind direction started in 1953.

Table 5 shows the number of stations used to construct the interpolated data set, according to climate parameters and regions. (This table does not show the total number of stations operating in each jurisdiction; additional stations operate outside the interpolation area. The total also does not represent the actual number of weather stations operating at any given time. Weather stations sometimes move to a nearby location, close or encounter program changes, resulting in double counting and a larger overall total.)

Interpolation methods and interpolation error

Many interpolation methods are available, with different strengths and weaknesses. The interpolation method used for the maps in this Atlas depended on the characteristics of the climate parameter.

Table 5. Number of weather and climate stations used to create the interpolated data set, 1901 to 2000

Country	Province	Temperature and precipitation	Wind	Relative humidity	Solar radiation
United States		239	6	6	2
Canada	Alberta	1,209	91	95	11
	British Columbia	757	166	74	7
	Saskatchewan	283	67	33	3
	Yukon, Northwest Territories, Nunavut	123	188	55	1
	Canada subtotal	2,372	512	257	22
Total number of stations		**2,611**	**518**	**263**	**24**

Daily maximum and minimum temperatures at the midpoint of a township were obtained by a weighted average of the data from up to eight neighbouring stations. The weight of each station was ***inversely proportional*** to the distance between the station and the midpoint of the township. In this way, the value assigned to the township midpoint was influenced most strongly by the stations closest to the township midpoint. This is called the ***inverse-distance weighting method***. Other weighting schemes also exist for interpolations, to vary the relative importance of station proximity. For example, ***inverse-distance-square weighting*** further emphasizes the influence of closer stations over more distant ones by squaring all the inverse distances.

Daily precipitation can be very localized and highly spatially variable, particularly in the summer, when localized convective storms are the source of most precipitation events. Even for the areas with high station density like central and southern Alberta, one station may observe precipitation while a close neighbouring station observes none. The inverse-distance method results in too many days with precipitation in a month and too little precipitation for a given day, and so leads to falsely small spatial and temporal variations in the interpolated township data of precipitation.

To avoid this problem and to preserve the localized and highly spatially variable characteristics of precipitation, the ***hybrid interpolation method*** was used. The steps of this method are:

1. The inverse-distance weighting method described above is applied to the daily data to identify monthly precipitation totals for each township.

2. For each day of the month, the station nearest to the midpoint of a township is used as the reference station, to determine what proportion of the total monthly precipitation would be assigned to the township on that day. (This method of assigning a point the value of its nearest neighbour is called the ***nearest neighbour method*** of interpolation.) If no precipitation occurred at the nearest station, the proportion for that day is zero; if the nearest station received 25 per cent of its monthly precipitation on that day, the proportion is 0.25, and so on.
3. The amount of daily precipitation assigned to the township is the identified proportion from the nearest station for that day (step 2), times the monthly total precipitation estimated for that township (step 1).

The method preserves both the monthly precipitation totals and the number of days with precipitation (the precipitation frequency).

Few Alberta stations measure solar radiation, relative humidity, wind speed and wind direction. Therefore, these parameters are interpolated using the nearest neighbour method described above, which is better suited to sparse data. The climate value assigned to a township for a given day was the value observed that day at the station nearest to the midpoint of the township. This method is equivalent to the Thiessen polygon method described by Bootsma and Ballard (1999).

The assessment of the prevailing wind direction requires hourly data, which began to be collected in Alberta in 1953. The seasonal prevailing wind directions and average wind speeds are calculated for each station, and then township values are interpolated from these seasonal station values, using the nearest neighbour method.

The reliability of the interpolated data on townships has been tested for maximum temperature, minimum temperature, and precipitation. The test is done by pretending the absence of the data from a station with a long and continuous record of observations, like the Edmonton International Airport station. Then the daily climate values of the station location are obtained by interpolation. The difference between the observed values and the interpolated values indicates the reliability of the interpolated township data. This method of testing reliability is called ***cross-validation*** in statistics. Five stations with long, continuous records in the period from 1971 to 2000 were selected as the cross-validation stations, giving a full representation from the south to the north. Table 6 gives the information for the five stations.

Table 6. Stations selected for cross-validation

Environment Canada station ID	Station name	Latitude	Longitude	Number of continuous days
3033890	Lethbridge CDA	49°42'	112°47'	10,409
3023720	Lacombe CDA	52°28'	113°45'	10,957
3012205	Edmonton Int'l Airport	53°18'	113°35'	10,957
3070560	Beaverlodge CDA	55°12'	119°24'	10,956
3073146	High Level Airport	58°37'	117°10'	7,337

When interpolating from stations onto midpoints of townships for daily data, the ***root mean square errors***, which measure the difference between the interpolated and the true observed values, are in the following range: maximum temperature, 1.3 to 3.4°C; minimum temperature, 1.4 to 3.4°C; and precipitation, 2.4 to 3.4 mm.

The cross-validation method has also helped to select the best method of interpolation since many interpolation methods exist. For temperature and precipitation, the method used here has less error than the methods of simple nearest neighbour assignment, inverse-distance-square weighting, or ***kriging*** (see Matheron, 1963).

Relative humidity, radiation and hourly wind data are collected at very few stations. Cross-validation requires deletion of a station, resulting in a significant change of the original observational network for these three parameters. Thus, the cross-validation studies were not carried out in the error assessment for relative humidity, radiation, and wind.

Cartographic display

The interpolation procedures described above assigned values to whole townships. The maps in this Atlas were based on measures derived from these values. However, to avoid the blocky appearance of townships on the maps and to remove small anomalies, several ***smoothing*** procedures were applied. These techniques were applied to the derived measures only and used strictly for cartographic display; the underlying interpolated values were not affected in the Alberta agroclimate database.

Parameters for which values were assigned by the nearest neighbour method were re-interpolated to present a more continuous appearance. Centres were calculated for regions of equal value and assigned the value of the particular region they represented. The values for each township were then re-interpolated from these centres using the inverse-distance method. Parameters originally assigned by the inverse-distance or hybrid methods did not require this procedure.

For all parameters, a 1000-m grid was imposed on each township polygon and each cell of the grid assigned the interpolated value of the township in which it fell. The grid was then smoothed by applying a 50-cell by 50-cell mean filter. For each cell, this filter assigned the mean value of all the cells in a 50-km window.

To reduce the final digital file size, polygons were created by merging grid cells that fell into the same legend class. Polygon boundaries were generalized to eliminate the blocky appearance.

The wind direction that is most characteristic of a season is not always the most frequently occurring wind direction, nor the vector mean direction. In some cases, the second or third most common wind direction recorded at a specific station is characteristic of the season at the provincial scale shown here. Therefore the placement of arrows to show characteristic wind direction was based on expert knowledge, as well as prevailing wind data. Arrows showing seasonal characteristic wind direction were placed at the locations of specific stations, and other arrows were added between stations to give a visual sense of dominant airflow patterns.

Ducks Unlimited Canada

Alberta Agriculture, Food and Rural Development

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APPENDIX

Table A1. Frost dates for locations in Alberta's agricultural region*

Station location	Average date of first fall frost	Average date of last spring frost	Frost-free period
Aden	September 23	May 13	133
Alder Flats	September 14	May 21	116
Alliance South	September 9	May 21	111
Altawan	September 8	June 1	99
Andrew	September 16	May 21	118
Athabasca 2	September 11	May 21	113
Atlee	September 14	May 21	116
Baird Lake	September 3	May 18	108
Beaver Lake RS	September 14	May 24	113
Beaverlodge CDA	September 9	May 23	109
Bellis	August 31	June 5	87
Berwyn CDA	September 9	May 18	114
Big Stone	September 17	May 22	118
Bow Valley Prov Park	August 25	June 2	84
Bowden	September 8	May 23	108
Breton	September 22	May 18	127
Brightview	September 17	May 16	124
Brooks ASCHRC	September 13	May 20	116
Brownfield	September 2	May 29	96
Caldwell	September 9	May 31	101
Calgary Int'l A	September 14	May 20	117
Calmar	September 14	May 19	118
Campsie	August 29	June 2	88
Camrose	September 16	May 15	124
Cardston	September 15	May 27	111
Carway	September 1	June 13	80
Cessford	September 8	June 6	94
Chailey	September 17	May 20	120
Chisholm Tower	September 5	May 25	103
Claresholm Waterworks	September 8	May 28	103
Clear Hills	September 9	May 24	108
Cochrane	September 8	June 1	99
Codesa Tower	September 12	May 19	116
Cold Creek RS	August 26	June 13	74
Cold Lake A	September 13	May 20	116

Table A1. Frost dates for locations in Alberta's agricultural region* *(continued)*

Station location	Average date of first fall frost	Average date of last spring frost	Frost-free period
Contracosta Lake	September 13	May 25	111
Coronation	September 12	May 19	116
Craigmyle	September 8	May 27	104
Dakota West	September 3	May 30	96
Deadwood Tower	September 10	May 23	110
Dickson Dam	September 18	May 12	129
Donnelly	September 9	May 24	108
Drumheller	September 17	May 19	121
Eckville South	September 6	May 28	101
Edmonton Muni A	September 24	May 4	143
Edmonton Int'l A	September 13	May 21	115
Edmonton Stony Plain	September 21	May 10	134
Edson A	August 31	June 8	84
Elk Point	August 29	June 5	85
Elmworth CDA	August 25	June 4	82
Empress	September 15	May 19	119
Enilda LO	September 14	May 21	116
Entwistle	September 16	May 21	118
Eureka River	August 18	June 13	66
Fabyan	September 10	May 25	108
Fairview	September 18	May 15	126
Five Mile Creek	August 18	June 23	56
Footner Lake A	August 29	May 29	92
Foremost	September 21	May 19	125
Forestburg Plant Site	September 26	May 7	142
Fort Assiniboine	August 30	June 6	85
Fort Macleod North	September 12	May 14	121
Fort Vermilion	September 2	May 23	102
Ghost Pine Creek	September 8	May 24	107
Gibbons	September 8	May 18	113
Gleichen	September 12	May 23	112
Glenevis	September 11	May 26	108
Grande Prairie A	September 11	May 18	116
Grovedale RS	August 22	May 24	90
Gwynne	September 9	June 1	100

Table A1. Frost dates for locations in Alberta's agricultural region* *(continued)*

Station location	Average date of first fall frost	Average date of last spring frost	Frost-free period
Hackett	September 12	May 23	112
Herronton East	September 13	May 19	117
High Prairie South	September 10	May 13	120
High River	August 31	June 9	83
Highvale	September 26	May 11	138
Hughenden	September 3	May 25	101
Jarvie Hamlet	September 7	May 22	108
Jenner	September 12	May 14	121
Keg River RS	September 6	June 2	96
Keoma	September 8	May 24	107
Kinsella Ranch	September 14	May 13	124
Kinuso	September 9	May 28	104
Knight Lake	August 23	June 8	76
Ksituan	September 7	May 24	106
Lacombe	September 6	May 27	102
Lamont	September 14	May 22	115
Lethbridge A	September 18	May 17	124
Lethbridge CDA	September 20	May 20	123
Lloydminster A	September 15	May 19	119
Madden	September 11	May 25	109
Manning A	September 3	May 22	104
Manyberries	September 19	May 16	126
Masinasin	September 19	May 22	120
Medicine Hat	September 23	May 14	132
Medicine Lodge LO	August 25	June 12	74
Millarville	August 19	June 22	58
Mirror	September 8	May 17	114
Monarch	September 9	May 29	103
Namao	September 21	May 11	133
New Brigden East	September 9	May 8	124
Olds	September 12	May 21	114
Oregon Flats	August 31	June 1	91
Oyen Cappon	September 18	May 18	123
Paradise Valley	September 9	May 26	106
Peace River A	September 8	May 21	110

Table A1. Frost dates for locations in Alberta's agricultural region* *(continued)*

Station location	Average date of first fall frost	Average date of last spring frost	Frost-free period
Picture Butte West	September 20	May 11	132
Pincher Creek A	September 16	May 20	119
Pollockville	September 1	May 24	100
Porcupine LO	September 8	June 15	85
Puskwaskau	September 6	May 23	106
Queenstown	September 18	May 20	121
Ranfurly	September 7	May 22	108
Red Deer A	September 12	May 20	115
Rimbey	September 3	May 18	108
Rocky Mtn House A	September 2	May 21	104
Ronan	August 28	June 10	79
Saddle Hills LO	September 6	May 25	104
Scapa	September 12	May 24	111
Schuler	September 15	May 25	113
Scotfield	September 1	May 29	95
Sedalia East	September 19	May 13	129
Sedgewick	September 13	May 19	117
Shining Bank	September 3	June 7	88
Sibbald	September 8	May 26	105
Sion	September 16	May 16	123
Spirit River RS	September 18	May 9	132
St Lina	August 26	June 7	80
Stettler	September 15	May 24	114
Strathmore East	September 11	May 22	112
Suffield A	September 19	May 17	125
Sundre Garrington	September 3	May 27	99
Taber	September 22	May 10	135
Three Hills South	August 28	May 24	96
Tofield North	September 14	May 25	112
Trochu	September 13	May 19	117
Tulliby Lake	September 4	May 24	103
Valleyview RS	September 18	May 9	132
Vauxhall North	September 16	May 18	121
Vega LO	September 12	May 16	119
Vegreville	September 12	May 23	112

Table A1. Frost dates for locations in Alberta's agricultural region* *(continued)*

Station location	Average date of first fall frost	Average date of last spring frost	Frost-free period
Venice	August 29	June 6	84
Viking	September 13	May 23	113
Vulcan	September 17	May 21	119
Wainwright	September 2	May 22	103
Wandering River RS	September 3	May 26	100
Wanham CDA	September 8	May 16	115
Warner West	September 24	May 14	133
Warwick	August 27	June 3	85
Waterton Lakes R Cabin	August 17	June 17	61
Watino	September 17	May 19	121
Wetaskiwin South	September 18	May 14	127
Whiskey Gap	September 5	June 11	86
Whitecourt A	September 9	May 22	110
Whitemud	September 11	May 23	111
Wildwood Newbery	September 1	June 11	82
Winfield	September 2	May 31	94
Woking CDA	August 30	June 5	86

** The stations used in this table have data for 13 or more years during the period from 1971 to 2000.*

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